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Homestretch
— by —
Antonis Achilleos, busboy

A strange sporting event took place the other day. A man in a fetal position under a hurdle caught a runner in midair.

Is this fun, or what?



Antonis Achilleos, pro busboy, amateur shooter, dove under a hurdle to catch a flying woman with his Nikon N6006. Please don't try this at home.

To Antonis Achilleos, part-time busboy, full-time amateur photographer, it is. In fact, to Antonis, making great photographs is more fun than making touchdowns, jump shots or holes in one.

One afternoon, while driving to get a Slurpee, he spotted a vision of beauty in sweat socks flying through the air.

Something clicked.

He grabbed his Nikon N6006, leaped out of his car, then flung his body under a hurdle and waited. Was it worth it?

What do you think?

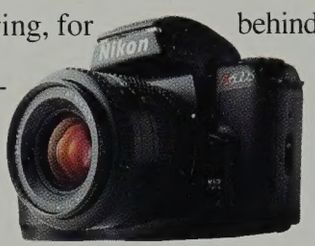
Antonis used an N6006 to experiment with and expand creativity.

It autofocuses quickly and precisely in light as dim as a single candle. There's Spot Metering, Center-Weighted Metering, and Matrix Metering, for rapidly changing light conditions or fast-moving action.

"Hey, Mister, duck!"

There's a powerful pop-up flash with 28mm coverage. Here Antonis brightened the foreground by increasing the flash one stop. And he underexposed one stop to maintain the ominous sky and provide contrast to the brightly lit foreground.

To create a sense of motion (as if she needed it), he used Rear Curtain Sync, which fires the flash just before the shutter closes, and he shot at 1/15th. Even though the flash isn't designed to cover the entire frame, Antonis chose a 24mm AF Nikkor to exaggerate the angle. He could have picked any one of nearly eighty legendary lenses. The same lenses most pros use behind the dugout or in the end zone.



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NATURAL HISTORY
VOL. 102, NO. 1, JANUARY 1993



COVER: *The sharp-eyed praying mantis is a fearsome predator, but it also has to avoid some hungry enemies. Story on page 28. Photograph by Laura Riley; Bruce Coleman, Inc.*

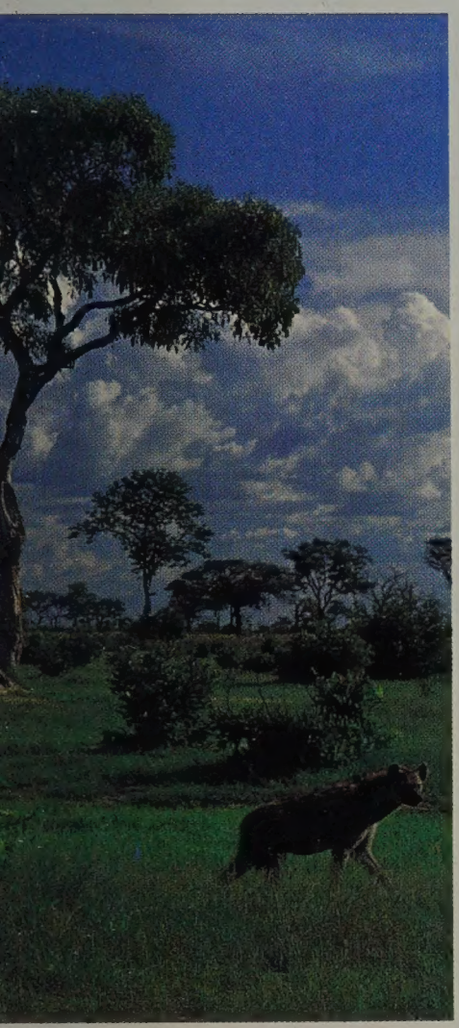
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A monthly magazine of the American Museum of Natural History

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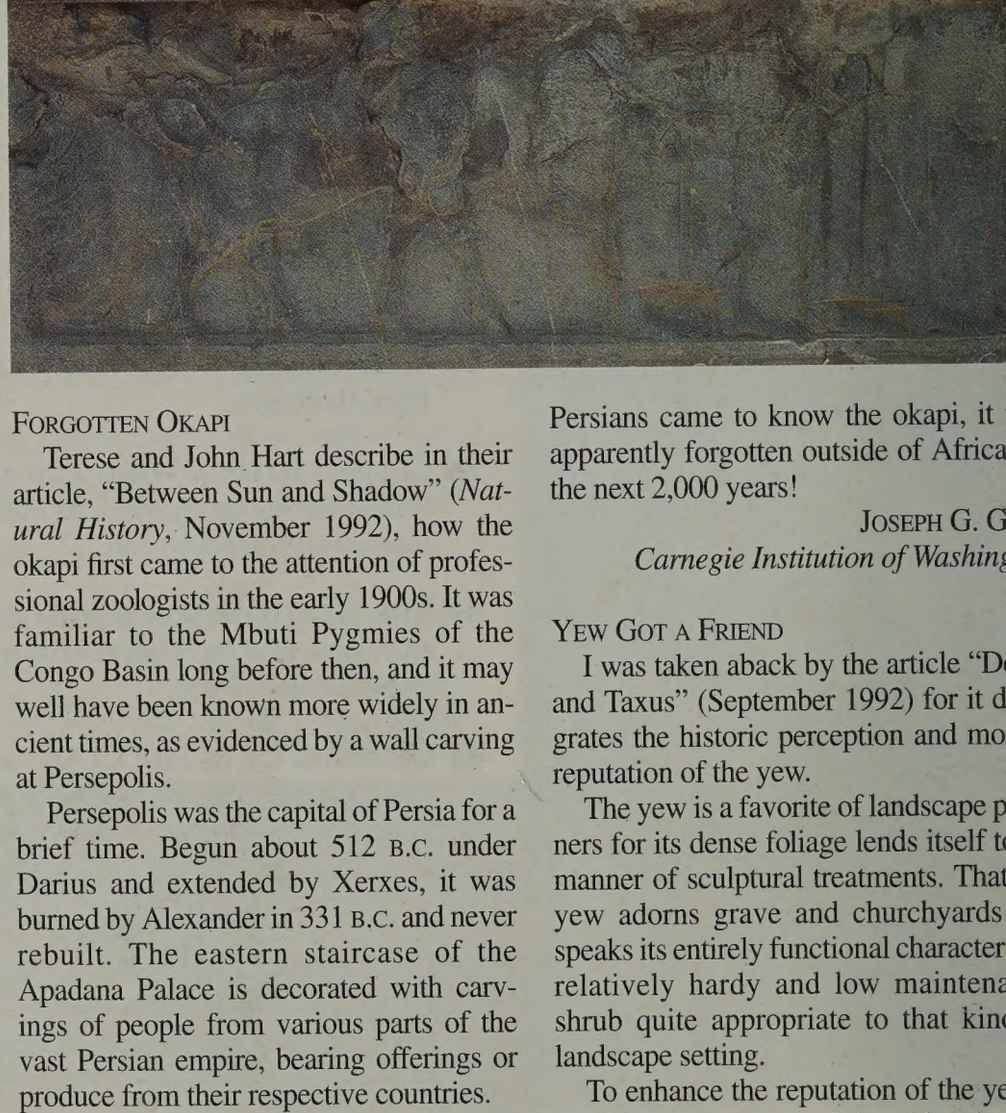
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LETTERS



FORGOTTEN OKAPI

Terese and John Hart describe in their article, "Between Sun and Shadow" (*Natural History*, November 1992), how the okapi first came to the attention of professional zoologists in the early 1900s. It was familiar to the Mbuti Pygmies of the Congo Basin long before then, and it may well have been known more widely in ancient times, as evidenced by a wall carving at Persepolis.

Persepolis was the capital of Persia for a brief time. Begun about 512 B.C. under Darius and extended by Xerxes, it was burned by Alexander in 331 B.C. and never rebuilt. The eastern staircase of the Apadana Palace is decorated with carvings of people from various parts of the vast Persian empire, bearing offerings or produce from their respective countries.

During a visit to Iran in 1976 I photographed one of these carvings, which shows an African, possibly an Ethiopian, carrying an elephant tusk on his shoulder and leading a neatly harnessed male okapi. Was this okapi actually transported to Persepolis, as suggested by the carving, or was it drawn on the basis of animals seen in Africa? Was the okapi widely known at that time, or was the one on the wall a unique specimen? Other animals in the same assemblage include lions, rams, bulls, horses, camels (bactrian and dromedary), and donkeys, none of which was particularly rare. By whatever means the Persians came to know the okapi, it apparently forgotten outside of Africa the next 2,000 years!

JOSEPH G. G
Carnegie Institution of Washing

YEW GOT A FRIEND

I was taken aback by the article "D and Taxus" (September 1992) for it d grates the historic perception and mo reputation of the yew.

The yew is a favorite of landscape p ners for its dense foliage lends itself t manner of sculptural treatments. That yew adorns grave and churchyards speaks its entirely functional character relatively hardy and low maintena shrub quite appropriate to that kin landscape setting.

To enhance the reputation of the ye would note that one of the oldest kn wooden artifacts, a fifteen-inch fragi including the pointed tip of a spear snow probe?), is a piece of yew from C ton-On-Sea, England. Apparently, English appreciated the yew early on their appreciation continued, for the was the favored wood for all sorts of uses. Perhaps most importantly, the provided the wood for the legendary l lish longbow. At the Battle of Agin Henry V's forest of yew brought dow flower of France in that very one-s and classic engagement. In a metapho sense, several thousand men with b

, lances and spears, all with shafts of could be regarded with some morbid- ut the qualities of the yew led to Eng- uccesses.

the seventeenth century, the technol- of the yew longbow and steel-tipped ys with English fletching was still dered a military secret. Early Span- nd French explorers recounted the ess of American Indian archery. That people were impressed could be because they both had long aban- d archery and shifted to the crossbow. use the English still had the yeoman tion, they respected Indian archers but not their bow-and-arrow technol- Fearful that the Indians would find what a "real bow and arrow" was t, the English at Bermuda interrupted ge shipment of several thousand bows thousands of sheaves of arrows con- ed to the colonies.

J. RICHARD SHENKEL
University of New Orleans

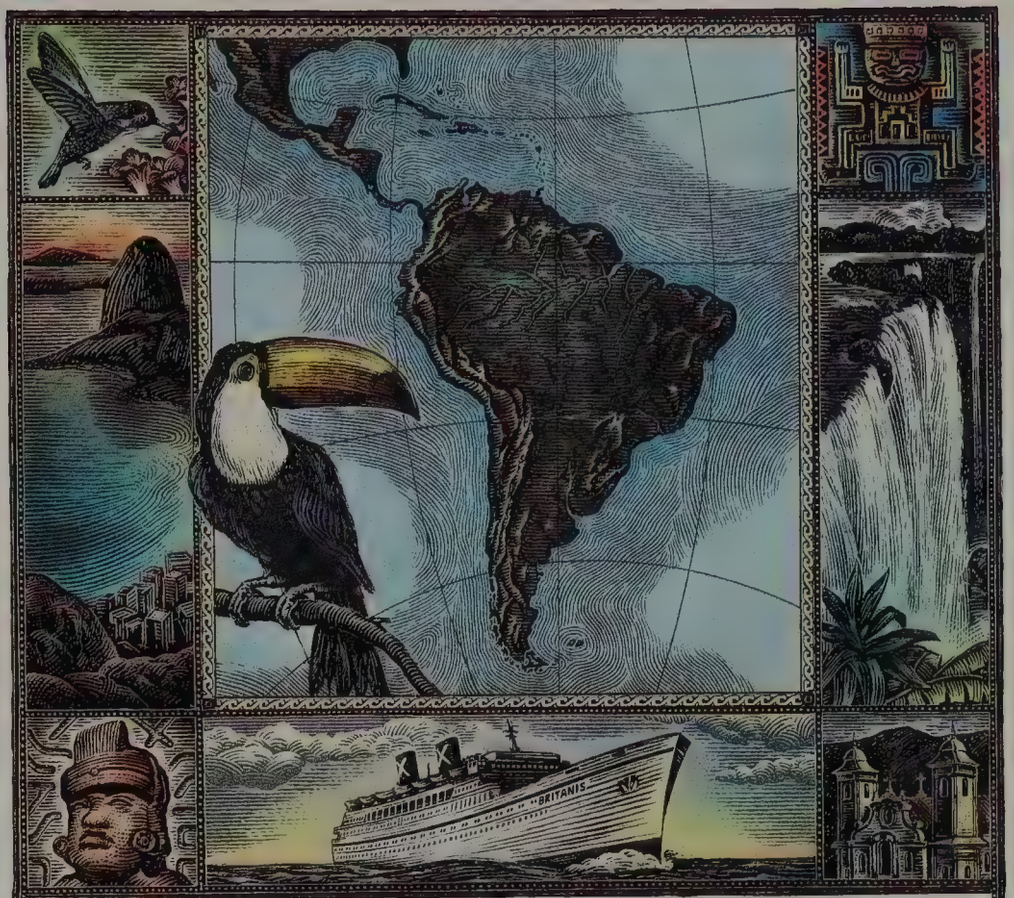
LOSER LOOK

hank you for the eloquent pho- aphs by Scott Altenbach and fascinat- piece by Anne Brooke on fishing bats ober 1992). I thought the enclosed o will give your readers a feeling of accurately Brooke describes the k pouches of *Noctilio* that can resem- 'small balloons tied beside the bat's "

heers for a magazine that will not stop rising and captivating us.

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A Special Fondness for Beetles

Haldane apparently had an inordinate liking for his quip, but never wrote it down

by Stephen Jay Gould

Just as the Lord holds the whole world in his hands, how we long to enfold an entire subject into a witty epigram. The quotable one-liner is a mainstay of culture, not an innovation in our modern era of sound bites. How could we grasp the eternal truths of nature and humanity if we couldn't ask Sam to play it again or didn't know that nice guys finish last.

The most widely quoted one-liner in evolutionary biology brilliantly captures the central fact about life's exuberant variety and composition. According to an older tradition that Darwin overturned, we should be able to infer both God's existence and his benevolence by studying the organisms that he created. This idea of "natural theology" dominated British zoology, at least from John Ray in the late seventeenth century to William Paley in the generation just before Darwin. The natural theologians sought God's handiwork not merely in the good design of organisms but especially in the supposed arrangement of nature to reflect human superiority and domination.

As a powerful corrective to this arrogant tradition of natural theology, evolutionists argued, early and often, that nature's undoubted order is neither benevolent in our terms (but "red in tooth and claw") nor established with us in mind or at the helm. The kind of God implied by nature's actual composition might not be a deity worthy of our worship.

At this point in the argument, almost any evolutionist will turn to our canonical one-liner for epigrammatic emphasis and support. J. B. S. Haldane (1892–1964), author of the phrase, was a founder of modern Darwinism (see his 1932 book, *The Causes of Evolution*) and a distinguished man of letters as well. I cite the famous words from the standard source—not Haldane himself, but a footnote on the first page of the most widely read paper in modern evolutionary biology: "Homage to Santa Rosalia, or Why Are There So Many Kinds of Animals" (*American Naturalist,* 1959), by G. Evelyn Hutchinson, world's greatest ecologist and the only twentieth-century British biologist who could match Haldane in brilliance and wit. Hutchinson wrote:

> There is a story, perhaps apocryphal, of the distinguished British biologist, J. B. S. Haldane, who found himself in the company of a group of theologians. On being asked what one could conclude as to the nature of the Creator from a study of his creation, Haldane is said to have answered, "An inordinate fondness for beetles."

Lovely line, but did Haldane utter it—and if so, when, where, and how? The standard source illustrates the problem—not hard copy with a byline, but a secondary report, frankly labeled as "perhaps apocryphal." Haldane was a brilliant and copious writer, but he was an even more fluent barroom wit—and great comments in this venue end up either scratched into soggy napkins or dimly remembered in the midst of a hangover.

Haldane's line—an inordinate fondness for beetles—is now so famous and standard that we really do yearn to pin down the source. Yet nothing is so elusive as a canonical well-turned phrase, for the vast majority of such quips are either misstated or misattributed (see *Nice Guys Finish Seventh: False Phrases, Spurious Sayings and Familiar Misquotations,* by Ralph Keyes, Harper Collins, 1992). I tried to slip two of them by you in my first paragraph. Leo Durocher did not confine angels to the cellar; and Humphrey Bogart (as Rick in *Casablanca*) never told Sam to play it again (although Woody Allen purposely used this standard error as the title for a film).

Thanks to a charming, if somewhat cranky, English tradition—lengthy and passionate exchanges in letters to the
tor on the minute details of smallish
jects—we finally have both as good a
olution as we can get, and a catalog of
usual mistakes that make canonical qu
tions so hard to trace. It all started in
October 5, 1989 issue of *Nature,* when
friend (an Oxford professor) Bob May
viewed a meeting on interactions betw
ants and plants under a title that paro
Haldane's quip—"An Inordinate Fo
ness for Ants." May began his arti
"Haldane's best-remembered remark,
God has 'an inordinate fondness for
tles,' was elicited by Jowett's questio
high table at Balliol, as to what his stu
had revealed about the deity." This elic
a firestorm—for reasons that will soo
obvious—and the "letters" column
both *Nature,* Britain's leading professi
journal in general science, and *The
nean* (newsletter of the Linnean Socie
London) have featured a burgeoning
now finally petering) exchange on the
ject ever since.

I do not trace the history of this can
cal line in the interests of antiqua
pedantry, but because the enterprise
yield such rewards in teaching us a
crucially important, and often unre
nized, biases in our modes of thought
styles of storytelling. (Since so muc
scholarship is, in effect, storytelling, t
biases often permeate the supposedly
thoughtful and rigorously objective
investigations.) The pervasive errors
in citing and attributing canonical qu
tions are not random, but follow a
and sensible pattern. Basically, most e
are aggrandizements in three categori
misattributions to more famous peopl
casting to render a quote more pith
pungent, and alteration of circumsta
to make the relatively mundane either
nier or more heroic. Let me illustrate
Haldane's quip about beetles has

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lowed in all three categories of usual error, and how—happy ending—we can home in on an accurate resolution that still leaves Haldane with a bloody good line.

Who said it? Haldane was sufficiently famous to win exemption from the "magnet effect"—the directed migration of good quotes to more celebrated mouths. No biologist of Haldane's generation could have made the quote more notable by assuming false parentage. But any evolutionary one-liner in English must eventually wander toward that greatest of all prose mongers in our profession, Thomas Henry Huxley. I have four misattributions of the beetle line to Huxley in my files (this essay has been gestating for more than a decade), and the same error may have prompted the howler that unleashed the recent round of discussion in *Nature* and *The Linnean*—Bob May's statement that Haldane made the quip to Benjamin Jowett at Balliol.

Jowett was the greatest English classical scholar of his day. His erudition and arrogance, as master of Balliol College, prompted a notable couplet in the annals of humorous verse:

> I am the master of this college;
> What I know not is not knowledge.

The pious and conservative Jowett would have been a perfect foil for Haldane's remark—but for one small problem. Jowett died in 1893 before Haldane had even reached his first birthday. (My freshman philosophy course in college still used Jowett's translation of Plato's *Republic*.) Jowett must have entered the story through misattribution of the beetle quote to Huxley (a contemporary who died in 1895), or perhaps to Haldane's father, a famous physiologist in his own right.

Bob May is an Australian, not an upper class English Oxbridgian. But his response to learning about his mix-up of generations, published in *Nature* on October 26, 1989, was both gorgeously arch and blessedly brief: "Mundane constraints of time and space do no apply to stories about Oxford."

In what circumstances? As May noted, good stories require the transmutation of the mundane into the charming, the amusing, or the dramatic. Haldane, as we shall see, made the quip several times, but always among friends. Yet the story improves immensely if the line can be recast as a spontaneous riposte to a specific taunt or to a query from a worthy adversary. Most versions therefore add this common element of myth. May used the shade of Jowett as an impossible foil. Hutchinson reported that Haldane had uttered the line in response to a specific query from theologians. A. J. Cain, another distinguished British biologist who knew Haldane well, wrote in 1987: "It was Haldane, not Huxley, and he told the story to me himself.... Some solemn ass asked him what could be inferred of the work of the Creator from a study of the works of Creation...and got the crushing reply 'An inordinate fondness for beetles.' "

With what words? The flurry of letters in *Nature* and *The Linnean* have validated Haldane as the source of our finest one-liner; at least no earlier version has been uncovered. Moreover, we can be fairly confident that Haldane did not utter the line in the "best story" situation of a riposte or retort; at least no victim or witness has come forward. But as we resolve these questions of personality and circumstance, the basic issue of Haldane's actual words remains elusive. Strange adventure: Haldane was a great writer and author of several popular volumes of scientific essays (most based on his columns in Communist *Daily Worker*—another triguing aspect of his iconoclastic ca but best saved for another essay). He parently loved his quip about beetles used it often in casual conversation public addresses. But no one has found any evidence that he ever wrot line down—and we therefore do not k exactly what he said (or if he varied words).

The closest thing to an "official" sion emerged as a result of all the re correspondence. On April 7, 1951, dane filled in for an indisposed collea the great physicist J. D. Bernal, to de an address to the British Interplanetary ciety. He did not publish his remarks, b report of his speech, written by the s ety's secretary, did appear in volume 1 the *Journal of the British Interplane Society*—a publication that will no found in your local library, not to men your corner drug store (and another rea for delayed documentation of Halda remark). I present the full citation:

> Coming to the question of life being fo on other planets, Professor Haldane ap gized for discoursing, as a mere biolo on a subject on which we had been exp ing a lecture by a physicist. He mentio three hypotheses:
>
> (*a*) that life had a supernatural origin
> (*b*) that it originated from inorganic terials;
> (*c*) that life is a constituent of the U verse and can only arise from pree ing life.
>
> The first hypothesis, he said, should taken seriously, and he would proceed t so. From the fact that there are 400,000 cies of beetles on this planet, but only 8, species of mammals, he concluded that Creator, if he exists, has a special prefere for beetles.

Fine. But have we now been depri of the delicious words in our usual c tion? Did Haldane really say "special p erence," and not the much more pung and ironic "inordinate fondness?" Is usual version just another example c falsely "promoted" quotation? Or did secretary of the Interplanetary Society ther misremember or downgrade in best tradition of British understateme Or did Haldane say different things at ferent times? We shall never know, bu letter in *The Linnean* (August 1992) fr Haldane's friend Kenneth Kermack stores our hope for accuracy of the us version:

> I have checked my memory with Do [Kermack's wife] who also knew Hald

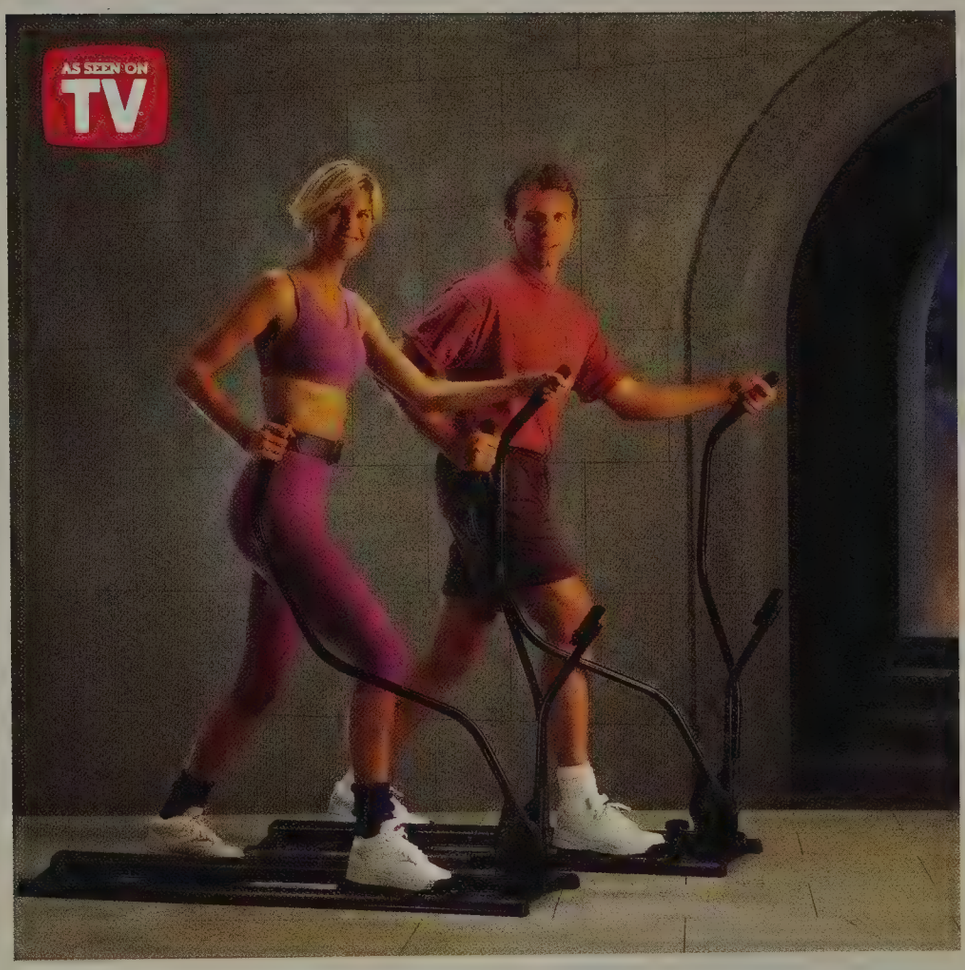


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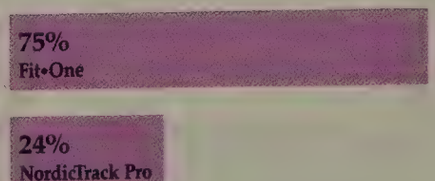
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well, and what he actually said was: "God has an inordinate fondness for beetles." J. B. S. H. himself had an inordinate fondness for the statement: he repeated it frequently. More often than not it had the addition: "God has an inordinate fondness for stars and beetles."... Haldane was making a theological point: God is most likely to take trouble over reproducing his own image, and his 400,000 attempts at the perfect beetle contrast with his slipshod creation of man. When we meet the Almighty face to face he will resemble a beetle (or a star) and not Dr. Carey [the Archbishop of Canterbury].

So pay your money and take your choice. You can either select the duller "special preference" for beetles alone, or you must share the wittier "inordinate fondness" with all the celestial multitudes. I have made a hybrid compromise in the title of this essay.

But what about the facts of the case? How inordinate is God's fondness, how special his preference, for the Coleoptera? How many species of beetles do inhabit our planet—and what, pray tell, does it all mean? In the best and most recent summary of data, British Museum entomologist Nigel E. Stork reports that the total number of formally named species of animals and plants (excluding the diverse kingdoms of fungi, bacteria, and other unicellular creatures) now stands at approximately 1.82 million. ("Insect Diversity: Facts, Fiction and Speculation," *Biological Journal of the Linnean Society,* vol. 35, pp. 321–37). Of these, more than half are insects (57 percent)—and nearly half of all named insect species are beetles. Thus, beetles represent about 25 percent of all named species in the plant and animal kingdoms—good candidature, I trust we would all agree, for inordinate fondness.

But this compendium of available names is only a beginning, a tip of the proverbial iceberg. All taxonomists agree that the vast majority of earth's species remain undiscovered and unnamed. In his recent book *The Diversity of Life* (Harvard University Press, 1992), my colleague Ed Wilson writes:

> How many species of organisms are there on earth? We don't know, not even to the nearest order of magnitude. The numbers could be close to 10 million or as high as 100 million. Large numbers of new species continue to turn up every year. And of those already discovered, over 99 percent are known only by a scientific name, a handful of specimens in a museum, and a few scraps of description in scientific journals. It is a myth that scientists break out champagne when a new species is discovered. Our museums are glutted with new species. We don't have time to describe more than a small fraction of those pouring in each year.

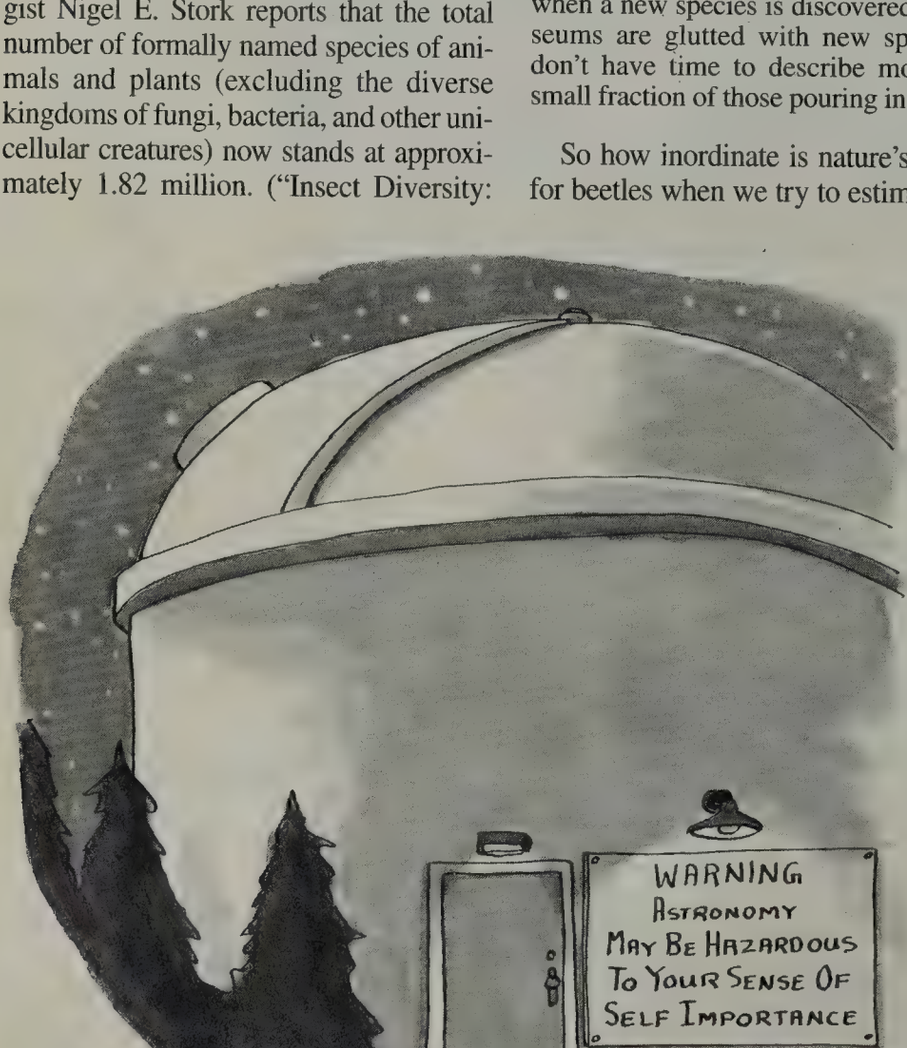
So how inordinate is nature's fondness for beetles when we try to estimate actual numbers, rather than relying on the p ness of published information? The for beetles now grows mightil strength—not only for the obvious solute gain in number of species, bu marily for increasing domination in tive frequency, or percentage of spe For beetles, by their size and fav places of abode, rank with the most u counted groups of organisms.

A complete census of species wil add membership equally and across board—for in some groups we nearly them all; while in others we have b begun to count. The worldwide com of bird watchers, for example, has bee assiduous—while the objects of s tend to be relatively conspicuous—tha expect no great increase in the 9,000 named species of birds. The influx of bird species has already dwindled to merest trickle, with only a species or added each year. Similarly, the ledge 4,000 or so mammalian species, while so diligently cataloged as birds, will e rience no massive gain in novelty.

But beetles are small and mostly in spicuous—and even the prominenc some as agricultural pests does not lea discovery for the majority, especi since most beetle species have limited ographic ranges in restricted habitat the world's most lush and understudied vironments: the tropical rain fore (When we realize how many species main unknown in this abode, and when recognize how many are being lost d as human rapacity clear cuts these rich vironments, usually for the short-t profits of a few, we can appreciate the propriate focus of the environme movement on tropical rain forests, e though these habitats may seem so dis from most of our immediate concerns locales.)

We may get some handle on the pro ble number of beetle species by consi ing the basis for lowest and highest e mates of the world's fauna and flora. Wilson cited 10 to 100 million as his la ballpark figure. I have read estimates ra ing from 1.87 to 80 million for inse alone—leading to some 3.5 million more than 150 million animal and pl species altogether, if insects are about the total.

The basis for this small biological dustry of estimation lies in some rema able work by the American entomolo Terry Erwin, published in the early 198 (Erwin was the first to give us a reasona quantitative estimate for the incredib



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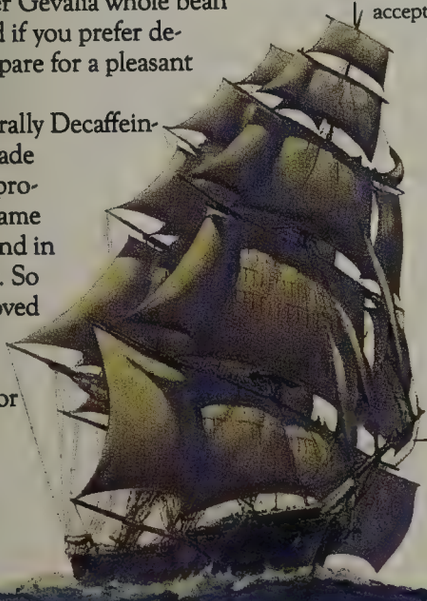
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and uncataloged, diversity of tropical rain forests—a vital contribution both to biological knowledge and to strategies of the environmental movement). In 1982, Erwin presented a surprising number that, although hard to believe at first, has since become a standard figure, cited in countless textbooks and newspaper articles. Erwin concluded that 30 million species of arthropods alone dwell in tropical rain forests—and he based his estimates on beetles.

Erwin's number comes from hard work in the field, not from a pocket calculator consulted in an armchair. He began by recognizing that insects cataloged from rain forest trees are a pitiful fraction of the enormously diverse community actually living in these tropical heights. But how can a scientist census all (or even most) of the species in a tall tropical tree; so many are rare, inconspicuous, and downright secretive in their habits. Erwin therefore used a drastic approach: he fogged entire trees with volleys of strong insecticide and collected what fell out. (I don't mean to sound peremptory or facetious; such work is rigorous and difficult, both conceptually and muscularly. How do you climb trees to fog? How do you collect the resultant bounty? How do you know that you have recovered most of the species [for some die deep in the bark and do not fall out]? Above all, how do you identify the plethora of previously unknown forms, especially since no one can be an expert on all groups?)

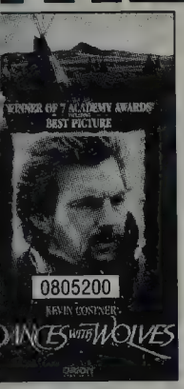
Erwin reached his figure of 30 million by extrapolating from the beetles on a single species of tropical tree, the legume *Luehea seemannii.* Consider this argument in eight steps, and you will begin to appreciate both the difficulty of the enterprise and the reasons for such a wide range of estimates.

1. Working in all three seasons recognized in the Panamanian rain forest, Erwin fogged nineteen trees of *Luehea seemannii*—thus getting a handle on variation among trees and seasons.
2. He counted the total number of beetle species recovered at some 1,200.
3. Erwin then assigned each species to of four guilds or ecological roles habitat herbivores (plant eaters), fu vores (feeders on fungi), predators, scavengers.
4. As a key problem in moving from b tles on a tree to insects in a forest, must know how many of these bee live exclusively on one kind of tree, how many are more cosmopolitan. for example, all 1,200 beetles lived o on *Luehea,* then the total number in forest may be as high as 1,200 times number of tree species. But if all 1, beetles live on all forest tree spec then the total number of beetles may just 1,200, period.) Erwin made his vision into guilds in order to estim this degree of "endemicity" (defi here as confinement to a single tree s cies). He arrived at estimates of 20, 5, and 5 percent, respectively, for four guilds of herbivores, fungivo predators, and scavengers.
5. Applying these indices of endemicit the 1,200 beetle species collected *Luehea,* Erwin estimated that 163 s cies might be confined to life on *L hea.*
6. Worldwide diversity of tropical tr probably stands at some 50,000 spec If 163 is a reasonable average for demic beetles per tree species, th tropical trees house 50,000 x 163, 8,150,000 species of beetles.
7. Since beetles represent some 40 perc of total arthropod diversity, tropi trees may house some 20 million s cies of arthropods.
8. This estimate of tropical diversity o counts species in tree canopies. Er then figured that canopy species mi outnumber ground-dwelling species about two to one—adding another million arthropods for the forest flo and raising the final estimate to 30 m lion.



The lower and higher figures of 1 million and 80 million for rain for arthropods arise from other data or dif ent estimates upon figures used by Er for extrapolating, not from challenges his empirical counts in fogging *Lue* trees. For example, Nigel Stork's high estimate of 80 million arises from t modifications of Erwin's figures, both s stantially raising the number of estima species. He believes that beetles repres far less than 40 percent of canopy arth pod species. Stork's preferred figure of percent immediately doubles the total e

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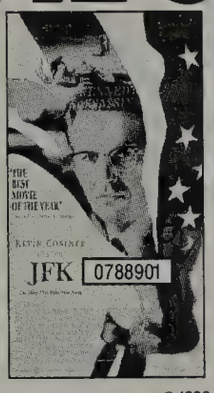














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mate for rain forest arthropods. Stork also argues that Erwin overestimated the percentage of species in the canopy versus the forest floor—thus yielding the still higher total of 80 million species when the right figure for ground dwellers is factored in.

The lowest estimate of 1.87 million comes from a 1991 article by I. D. Hodkinson and D. Casson that used for its title a parody on Haldane's quip: "A Lesser Predilection for Bugs: Hemiptera (Insecta) Diversity in Tropical Rain Forests" (*Biological Journal of the Linnean Society,* vol. 43, pp. 101–109). "Bug" may be a vernacular term for any creepy-crawly (not to mention errors in computer programs and illicit listening devices). But to a zoologist, "bug" is a technical term for insects of the order Hemiptera (often called true bugs in the literature for proper distance from ordinary usage). Hodkinson and Casson used bugs rather than beetles to make their worldwide estimate, and their sly title is a double entendre, for bugs are not nearly so rich in species as beetles in nature, and the authors' estimate of total arthropod diversity is also far smaller than most others offered of late.

As Erwin extrapolated from beetles on nineteen trees, Hodkinson and Casson worked upward "from an intensive study of the bug (Hemiptera) fauna of a moderately large and topographically diverse area of tropical rain forest in Sulawesi Utara, Indonesia." In broadest outline, Hodkinson and Casson followed the same logic that Erwin had employed. They collected 1,690 species of bugs from Sulawesi and determined that 62.5 percent had been previously unknown. If the 500 described species of Sulawesi trees yielded 1,056 new species (the total of 1,690 species times 62.5 percent for the proportion of newly found forms), then the worldwide figure of approximately 50,000 species of topical trees might yield 100 times as many new species of bugs, or 105,600. Add these to the 81,700 species already described for a total estimate of 187,300 bug species worldwide. Since bugs are about 10 percent of all insect species, the worldwide fauna of insects might stand at some 1.87 million.

How can two estimates based on the same style of argument be so different? The logic, as all people who do this work know only too well, is "iffy" in the extreme, for the conclusions are only sound if the premises be true—and why should endemic beetles on one kind of tree in Panama, or true bugs in one small region of Indonesia, be a model or average for estimating an entire world's fauna? Erw estimates may be way too high bec legume trees house more species most others (and a figure derived f them alone will vastly overestimate wo wide diversity), or because he gre overstated the number of beetles uniqu each species of tree (this has been the m common and cogent criticism of Erw estimate). Hodkinson and Casson's mates may be way too low because t area of Indonesia is relatively poor in cies, or because they did not use so c prehensive a collecting method as fog trees, and may therefore have misse substantial fraction of diversity.

In any case, we certainly learn that ture's fondness for beetles is vastly m inordinate than a simple count of 400 formally named species (Haldane's st basis for his quip) would indicate. We understand, from our great difficulty in timating the true number of species earth, and from the vast differences am figures offered by our best experts, h preciously little we know about the nat history of our planet. The next time so one tells you that taxonomy is a dull s ject because we have just a few detail fill in upon an earth already well know laugh in his face.

In the midst of this ignorance, should take comfort in two conjoined tures of nature: first, that our world is credibly strange and therefore supren fascinating (the real point, I think, beh Haldane's quip that ultimate mean must reside in the unparalleled diversit a group, beetles, that rarely rivets our tention); second, that however bizarre arcane our world might be, nature rema comprehensible to the human mind.

I should end by cementing these cardinal precepts with their canonical c liners. Einstein spoke for the possibilit grasping natural complexity when wrote, in a theological metaphor sec only to Haldane's on beetles: *Raffinier der Herr Gott, aber boshaft ist er n* (The Lord God is subtle, but he is not m licious.) As for the joy of nature's stran ness, we cannot do better than a fam line by a chap named J. B. S. Haldan and this time we know what he said cause he wrote it down! "My suspicio that the universe is not only queerer t we suppose, but queerer than we *can* s pose" (from *Possible Worlds,* 1927).



"Excuse me, but could you direct me to the Hayden Planetarium?"

Stephen Jay Gould teaches biology, ge ogy, and the history of science at Harv University.

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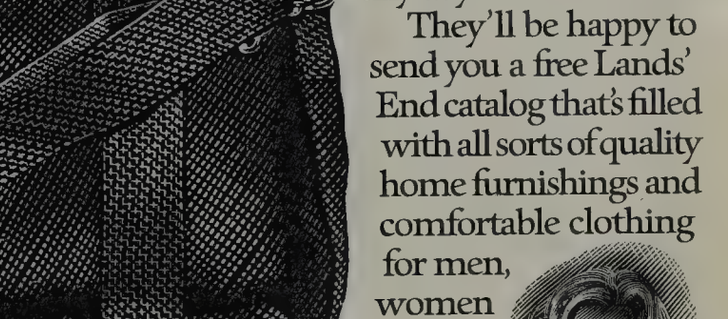
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Species in a Bucket

For a few frightening moments, there was only myself standing between life and extinction

by Edwin Philip Pister

[The naturalist] looks upon every species of animal and plant now living as the individual letters which go to make up one of the volumes of our earth's history; and, as a few lost letters may make a sentence unintelligible, so the extinction of the numerous forms of life which the progress of cultivation invariably entails will necessarily render obscure this invaluable record of the past. It is, therefore, an important object [to preserve them].... If this is not done, future ages will certainly look back upon us as a people so immersed in the pursuit of wealth as to be blind to higher considerations.

Alfred Russel Wallace
Journal of the Royal Geographical Society (1863)

When I retired in 1990, I built a small office in my backyard, equipped it with a phone and word processor, and began to reflect seriously upon a career that began in 1951 and continues even in retirement. I remain keenly aware of the legendary biologist Aldo Leopold's admonition that one of the penalties of an ecological education is that one lives alone in a world of wounds.

Virtually my entire career was spent as a district fishery biologist for the California Department of Fish and Game in the state's vast eastern sierra and desert regions. I worked on a great variety of management and research programs—from trying to keep millions of sports fishermen supplied with trout to preserving the biological integrity of desert springs that support life forms totally unknown to most Americans and even to most scientists.

Having studied wildlife conservation at Berkeley in 1948 under the tutelage of Aldo Leopold's son, A. Starker Leopold, I was exposed to the Leopolds' passionately held values regarding the natural world. Impressed by their view that nonconformity is the highest evolutionary attainment of social animals, I carefully avoided the usual career track that would have landed me in one of my department's major offices in a big city. As a graduate student, I had specialized in limnology, the study of freshwater lakes, and was given the responsibility for nearly a thousand bodies of water extending from the crest of the Sierra Nevada eastward to the Nevada state line. I was especially intrigued by the diversity of the landscape in my charge; if I left the roadhead near the base of 14,494-foot Mount Whitney at 9:00 A.M., I could make a leisurely drive to the east and have my lunch 282 feet below sea level on the floor of Death Valley. This area's life forms are commensurately diverse.

Today I sit at my desk surrounded by forty little pocket diaries, each one summarizing a year of my career. So many memories and experiences are packed into these 2.5- by 4-inch volumes, which, together, fill less than a shoe box. Daily entries recall a multitude of experiences: scaling through the usual routine meetings, conducting a twenty-seven-year project to restore the California golden trout within the Golden Trout Wilderness (still in progress), fighting scores of ill-considered and highly destructive entrepreneurial invasions of valuable habitats and recreation areas, managing a legendary reservoir fishery where success is measured by tons of trout harvested, then moving 180 degrees from consumption to conservation by helping save the Devil's Hole pupfish (*Cyprinodon diabolis*), a battle carried successfully to the U.S. Supreme Court.

In 1976, the Court's landmark decision protected Devil's Hole—a swimming-pool-sized window into the underground aquifer and a disjunct portion of Death Valley National Monument—and its dependent life forms from the impact
nearby ranching operation. (The ranc
were consuming vast quantities of u
plenishable groundwater from an aq
that had been undisturbed since the P
tocene.) The smallest and most hi
evolved of the Death Valley system
fishes, the Devil's Hole pupfish has
isolated from nearby pupfish populat
for approximately 44,000 years. It exis
probably the most confined habitat of
vertebrate animal in the world: the ten
fifty-foot pool in which it has evo
since its isolation.

Of more than ten thousand entries
tained in my diaries, the date August
1969, stands alone as the most dram
and meaningful. Written with naïve un
statement: "Transplanted *Cyprinodo*
Fish Slough; purchased alkaline D-c
$2.00," this cryptic entry summariz
series of events that, had they not g
right, would have accompanied the gr
est tragedy of my career. As it turned
what happened that day simply un
scored the lessons I had learned ea
from the Leopolds and other ecolog
mentors. Perhaps such an experience
necessary for me to fully comprehend
a person's values, which serve as a c
pass in uncertain times, are in the long
vastly more important than the sport-f
ing technologies that have often cre
more problems than they have solved.

During the several pluvial period
the Pleistocene epoch, much of the G
Basin of the American West was cov
by large, freshwater lakes. With the
proach of the Holocene, these wa
shrank and largely disappeared, and fis
were isolated within the few remain
permanent aquatic habitats. In No
America, only the Cuatro Ciénegas
Coahuila, México, have as many well

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fined local populations (species confined to the very small, isolated habitats in which they evolved). The Death Valley drainage area of eastern California and western Nevada is comparable to Charles Darwin's Galápagos Islands and their finch populations. They constitute, in effect, islands of water in a sea of sand.

One such habitat exists in eastern California's Owens Valley, where the Owens pupfish (*C. radiosus)* has been evolving since the Pleistocene. Because of major habitat changes and the introduction of predacious gamefishes (a deadly combination) during the early part of the twentieth century, the Owens pupfish was gradually eliminated from a range that once covered vast marshlands. By the time it was scientifically described in 1948, the species was believed to be extinct. One of the Death Valley area pupfishes, all of which evolved in the absence of predatory fishes, the Owens is almost totally defenseless against such introduced predators as largemouth bass, which I call "chainsaws with fins." The Owens pupfish was among the first fishes to be designated an endangered species, a status that it unfortunately still retains.

Pupfishes (named for their frolicsome, playful behavior) are members of the killifish family, a group of fishes very popular among aquarium enthusiasts. The Owens pupfish is the largest of the nine Death Valley pupfishes, occasionally reaching two inches in length; the Devil's Hole pupfish rarely exceeds one inch. Habitats are varied. The Owens pupfish thrives in the shallow, warm water that hot summer days bring to desert marshes; this same habitat may be covered with an inch or two of ice during wintertime, when air temperatures drop below zero. Conversely, the Devil's Hole pupfish lives in the upper reaches of a cavern so vast that its depth has never been determined, and in water at a constant 92° F. All pupfishes are feeding opportunists, consuming immature insects and algae. They are also highly territorial.

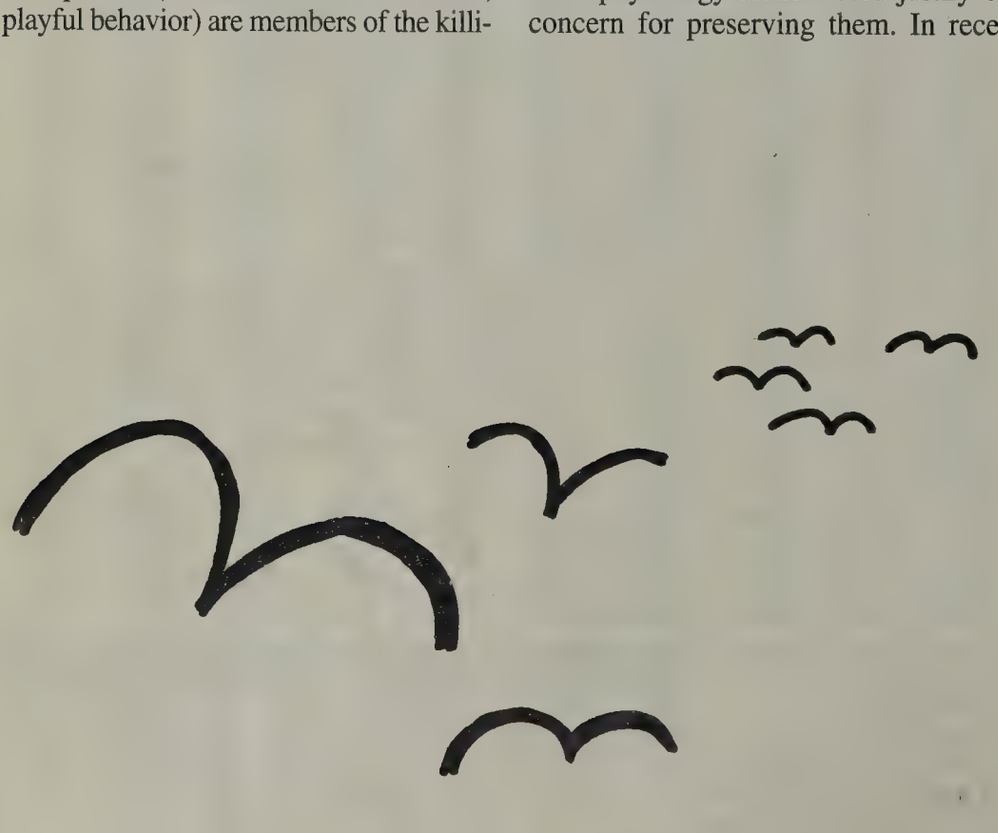
To survive in these rigorous habitats, pupfishes have evolved specialized adaptations. Some live in water that exceeds 100° F., and can tolerate up to 113° for short periods; daily fluctuations may be as much as 36°. Others live in pools with several times the salinity of seawater. The potential for research on the pupfishes is exciting. What they could tell us about kidney function, temperature tolerance and adaptation, and other areas of vertebrate physiology alone would justify our concern for preserving them. In recent years, however, it has been heartening note a shift in emphasis from what t can do for us to what we can do for the regardless of their potential value.

In 1964 researchers located a remn population of Owens pupfish in a des marshland called Fish Slough, a few mi from my home in Bishop, California. A covery effort was started by gradua reintroducing them into a few apparen suitable habitats, thereby getting a ju on the more sophisticated recovery p grams made possible later under the E dangered Species Act of 1973. These ea preservation efforts for fishes preceded relatively recent, and highly comme able, formalization of the science of c servation biology.

However, an unusual set of circu stances that began to coalesce in the l 1960s brought the Owens pupfish to brink of extinction. Without constant s veillance, which even now is very diffic for harried state biologists to maintain, pupfish gradually disappeared from th new homes and finally were confined t room-sized pond a short distance bel Fish Slough's northwest headwa springs. The winter of 1968–69 h brought heavy rains to the Owens Vall but by August the unusually thick vege tion was throwing off a great deal of mo ture, and an unexplained reduction spring flow contributed to the rapid dep tion of the pond. It was almost complet dried up when an alert assistant came in my office and announced: "Phil, if don't get out to Fish Slough immediate we are going to lose the species." His p nouncement was no exaggeration. It w the hard truth!

I stopped work on a trout manageme program for a major reservoir (the relati importance of the two projects has lo since served as a source of humor for m shouted a few words of explanation to c receptionist, and bolted for the door. Gra bing buckets, dip nets, and aerators, were joined by another colleague and i mediately headed for Fish Slough, n mally a fifteen-minute drive north of c office in Bishop (we shaved at least fi minutes off the usual driving time.) W hastened to the drying pond and carefu removed 800 remaining individuals, pla ing them in three wire mesh cages with the main northwest channel of the sloug in a diminishing flow already less than tw cubic feet per second. We planned to mo them later to safer locations within t same general area.

Having done all we could for the m



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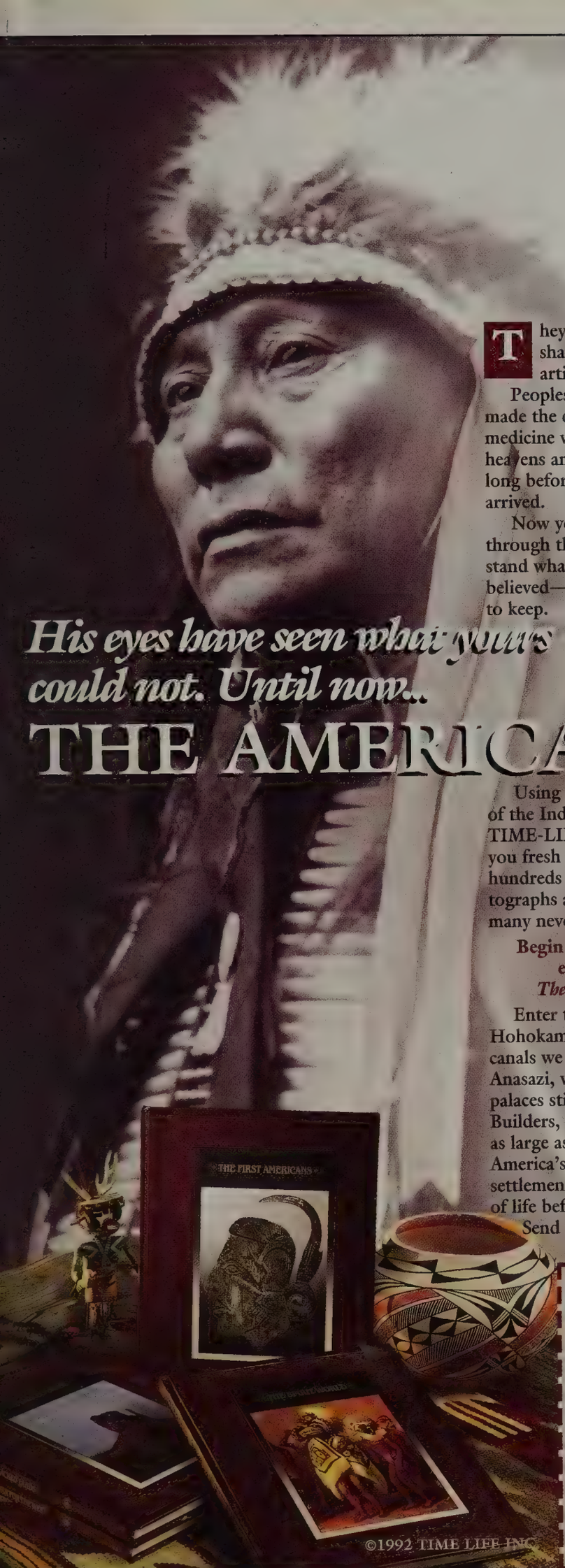
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ment, we decided to take a quick dinner break before returning to move half of the fish (about 400) across the slough to a location supplied by another spring source. In endangered species preservation work, a cardinal rule is always to place your eggs in more than one basket. We had come very close to witnessing a species extinction or, nearly as bad, a population so reduced in numbers as to eventually effect the same tragic consequence.

Temporarily alone in the marsh, I decided to make one final check (sometimes it pays to be a worrier). A glance into the nearest mesh cage showed that we were not yet out of the woods. In our haste to rescue the fish, we had unwisely placed the cages in eddies away from the influence of the main current. Reduced water velocity and accompanying low dissolved oxygen were rapidly taking their toll. When taken from their natural habitat, pupfish are fragile creatures. They were overcrowded in their cages and had been stressed by unavoidably rough treatment on a hot summer afternoon.

A number of dead and dying fish were already floating belly up or swimming irregularly, and it was clear that both mesh cages and fish would have to be moved immediately upstream to more favorable conditions nearer the springheads. I ran to my pickup truck and found only two buc ets (the other two were on their way ba to town). However, there were two ae tors available in addition to the all-imp tant dip net.

I netted the surviving fish into the buc ets, wincing as each dead one forcefu demonstrated the fragility of life. I then located the cages and returned to the buc ets, trusting that the battery-powered ae tors had not failed during my bri absence. Although the passage of time h obscured my exact words and thoughts I lugged two heavy buckets and their pr cious cargo (each weighing more th thirty pounds) over the treacherous mar terrain, I remember mumbling somethi like: "Please don't let me stumble. If I dr these buckets we won't have anoth chance!" I distinctly remember bei scared to death. I had walked perhaps fi yards when I realized that I literally he within my hands the existence of an ent vertebrate species. If I had tripped over piece of barbed wire or stepped into a r dent burrow, the Owens pupfish wou now be extinct! But good fortune smil upon us, and the recovery continues toda

Efforts to preserve endangered dese life forms never end, but essentially co stitute only a temporary reprieve aquatic habitats gradually decli throughout North America. Indiana Un versity's Lynton Caldwell, speaking of o environmental crisis, observed that wh endangered species are part of this lame table phenomenon, "more importantly, t crisis is concerned with the kind of cre tures we are and what we must become order to survive."

We have received adequate warni from our prophets. Aldo Leopold's "La Ethic," published more than forty yea ago in *A Sand County Almanac,* redefin Gifford Pinchot's "resource conservati ethic" (the greatest good for the greate number in the long run) and placed h mans as simply another species within t global ecosystem. This concept has sin become painfully obvious as we lea more about ourselves in relation to our e vironment.

Having spent much of the past tw decades responding to the cynical que tion: "What good are they?" (in referen to my efforts on behalf of the pupfish an similar "insignificant" organisms), I hav made use of an effective counterquer "What good are *you*?" (a very thoughtf question). I then add a Leopold corollar "To keep every cog and wheel is the fir

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caution of intelligent tinkering." ank-and-file American citizens have n generally apathetic about the conser- on of biological diversity, but one ld hope not to find similar unconcern in the scientific community. Yet there uch complacency among profession- particularly among those biologists ped within a tenure track and faculty ancement syndrome that often ranks ntity over quality in the research en- vor. If such scientists express an inter- n conservation, they usually are of the nion (naïvely and incorrectly) that neone else will attend to saving species. he 1992 annual meeting of the Ameri- Society of Ichthyologists and Her- logists, for instance, only a small per- tage of 385 research papers related to specific area of conservation.

Workers in the pragmatic field of con- vation biology frustrated by a critical d for answers to questions posed by cies recovery programs, draw analo- s of mowing the lawn while the house ns down. The possibility always exists, course, that *any* research, no matter how mingly esoteric, may someday be of ue in saving a species. Albert Einstein it this way: "I have little patience with entists who take a board of wood, look its thinnest part, and drill a great num- of holes where the drilling is easy." fortunately, the deadly serious matter preserving biodiversity generally places in the position of facing unpredictably k boards, full of knots, and then being ced to drill holes with a bit significantly led by the bureaucratic process.

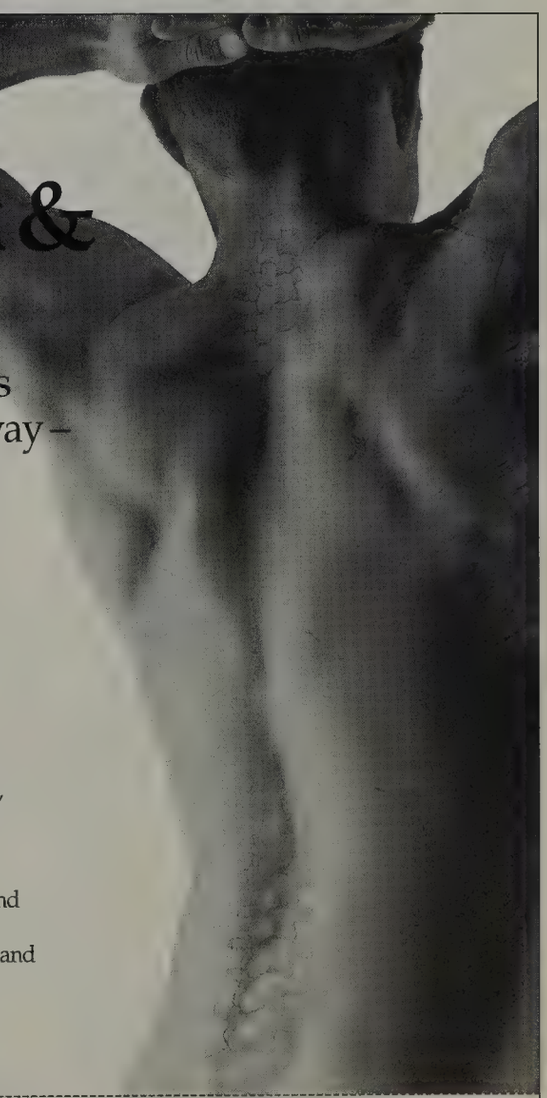
As I walked back to my truck following final transplant within Fish Slough, the had long ago set. In my dip net re- ined a few dead pupfish. I glanced up at darkening desert sky and thought of rre Teilhard de Chardin's concept of the nitely large, the infinitely small, and infinitely complex, represented here order) by the Milky Way, the pupfish, d the difficulty in pointing out the para- unt value of such things to an increas- ly materialistic society.

The day had been long. We had won an ly round in a fight that will inevitably ntinue as long as we have a habitable net. As a realist, I could not help but nder the ultimate fate not only of the vens pupfish but of all southwestern nes and species in general. I wondered out our future. Can the values driving industrialized nations be modified suf- iently to allow for the perpetuation of all species, including humans? Will we ever realize the potential implicit in our specific designation as *Homo sapiens,* the wise species? I hope the day will come when public policy will be guided by the wisdom of Aldo Leopold: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." Such recognition could constitute perhaps the first major step toward creating the sustainable society upon which our long-term survival obviously depends.

That August day twenty-three years ago had been a very humbling experience for me. The principles of biogeography and evolution I had learned many years before at Berkeley had taught me why the pupfish was here; it took the events of those few hours in the desert to teach me why *I* was. Such are the reflections of a biologist who, for a few frightening moments long ago, held an entire species in two buckets, one in either hand, with only himself standing between life and extinction.

Edwin P. (Phil) Pister is Executive Secretary of the Desert Fishes Council in Bishop, California. A former district fishery biologist for the California Department of Fish and Game, he now works to develop and promote conservation ethics.

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Close Encounters

by Gail S. Cleere

No other planet in the Solar System has elicited more excitement than Mars. Known since antiquity, Mars is easily recognizable by its color—blood red—and this easily explains its association with the gods of war, Nergal in Babylonia, Ares in Greece, and Mars in the vast Roman Empire. This month, the red planet rises in advance of sunset and is well up in the east at the end of evening twilight, near the twin stars Castor and Pollux in the constellation Gemini. Glowing brightly at -1.4 magnitude, Mars is high above the southern horizon about midnight. During the present passage of the earth between Mars and the sun, our planet makes its closest approach to Mars on January 3 (about 58 million miles away). Four days later it reaches opposition, meaning that Mars will be opposite the sun in our sky and therefore up for the entire night, making it a great time to look at this planet.

In earlier times, such a close approach of Mars would have seized the public's imagination. One hundred years ago, it was popularly believed that there was indeed life on Mars. After all, hadn't the Italian astronomer Giovanni Schiaparelli announced in 1877 that he had seen "canals" on Mars? Wasn't this obviously a sign of intelligence? And hadn't our own Percival Lowell confirmed this sighting with many of his own observations right here at home in Flagstaff, Arizona? These canals were assumed to be "stupendous systems of irrigation" bringing water down from the Martian poles to its "centers of population and industry." In 1910, the writer Garrett P. Serviss told us in *Curiosities of the Sky* that "the miraculous feat of engineering" was due to the planet's lower gravity force. Mars has an atmosphere, albeit thin, some water in its icecaps, and a surface temperature that is harsh but does not preclude life entirely. And so obviously, a close approach of the planet was the right time to communicate with our brothers on Mars. Their secrets could be revealed "from their own lips," Serviss wrote, "if we could get into wireless telephonic communication with the Martians."

Mars mania, as astronomer and writer Roger Sinnott calls it, increased during Martian oppositions. In 1898, H. G. Wells penned his classic *The War of the Worlds*. In 1909, there was a plan to spread an army of 5,000 men holding ten-cent shaving mirrors across Texas, ready to flash Mars in an attempt to signal intelligent life there. A wealthy Parisian widow offered 100,000 francs to anyone who was the first to communicate with a celestial body, with the exception of Mars, which would be too easy. During the Roaring Twenties, scattered radio signals thought to come from Mars inspired a touch of Mars mania in the Chief of Naval Operations, Admiral Eberle. He ordered many of the navy's huge radio stations to shut down transmissions for three days in August 1924 and listen for signals from Martians. Standing by to translate was the chief of the code section for the Army Signal Corps, who didn't crack any codes then but went on, Sinnott tells us, to crack the Japanese diplomatic code *Purple* just before World War II.

Two years later, in 1926, a Dr. Robinson in Hertfordshire, England, said he'd finally been in communication with Mars' inhabitants. During an interview, Robinson claimed that Martians had big ears, long hair, and Chinese features and that they smoked pipes, drank tea, and drove cars with weatherproof hoods. According to Sinnott, reporters walked out when Robinson started describing Martian "lower life forms." The notion of intelligent life on Mars had cooled down considerably by the 1930s, but not the notion of life itself.

The first successful flyby of the planet Mars was made in 1965 by the *Mariner 4* spacecraft. It was the first to transm close-up pictures of the planet's surfa *Mariner 9* continued the effort in 19 and the Martian features thus documen were given non-Anglo names, such Mangala, Mawrlth, Simud, and M (from Sanskrit, Welsh, Sumerian, a Nepali, respectively). Until Septemb with the launch of the Mars *Obser* spacecraft, the last missions to Mars h been the two *Viking* landings made 1976. The *Viking* landers analyzed the s face of the planet. With all their o "miraculous feats of engineering" a technology, they were unable to pro conclusively whether life on Mars exist

The Mars *Observer* spacecraft is sch uled to begin studying the planet when arrives late in 1993. It will be placed i low polar orbit and will study the plane atmosphere, surface, and interior over course of one complete Martian year equivalent to two Earth-years. In 1 1995, with the planned arrival of t Russian spacecraft carrying deployab balloons and surface packages, the M *Observer* will begin to relay data back Earth from these experiments. This inf mation will sharpen our understanding the similarities and differences amo Earth, Mars, and Venus and will help l the foundations for future expeditions the red planet. Given the curious history our interest in this planet, it is somewh ironic, astronomers point out, that if ever get there in a manned mission, will be the Martians.

The Planets in January

Mercury rises less than an hour befo sunrise at the beginning of the month a is very low in the southeast just befo dawn. By midmonth, the planet is t close to the sun to be seen, reaching sup rior conjunction (slipping behind the s from the earth's point of view) on the 23

the end of the month, Mercury is set- g after the sun and is in the southwest- sky at sunset. But it is still too close to sun to be easily seen.

Venus is a brilliant -4.4 magnitude this nth in the southwestern evening skies. ly in the month the planet is not far m Saturn. As the month progresses, urn pulls farther and farther away to- rd the east, reaching its greatest elonga- n east of the sun on the 19th and leaving turn to succumb to the setting sun. tch as the planet skims the bottom of Great Square of Pegasus all month g. On the 26th and 27th, the waxing scent moon pays a call, forming a par- ularly attractive grouping on the 26th.

Mars rules the night in January and can found in the northeast in the constella- n Gemini about an hour after sundown. e red planet makes its closest approach the earth on January 3, which is also the ght of the Quadrantid meteor shower. the 7th and 8th, the full moon passes t below Mars. Watch Mars' changing sition each night near Gemini's bright rs, Castor and Pollux.

Jupiter is that brilliant object due south t before dawn, quite bright this month -2.1 magnitude. On the 14th, Jupiter and e last-quarter moon, together with the st-magnitude star Spica, form a bright angle about halfway up in the predawn uthern sky.

Saturn sets about three hours after sun- t at the beginning of the month, rapidly coming more difficult to spot in late Jan- ry skies. Passing on the far side of the n (superior conjunction) on February 9, e ringed planet will be visible in the edawn sky by early March.

Uranus and **Neptune** both reach con- nction with the sun on January 8, hidden ehind the sun as seen from the earth. nce last year, these two planets have een inching closer and closer together. On January 26, they will rendezvous (unfortunately hidden from us) and will be closer than they have been since 1821. They will not be so near again until the twenty-third century.

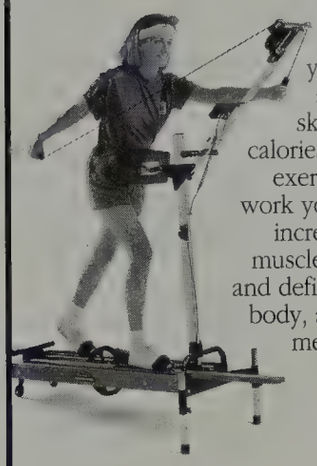
Early in the month, **Pluto** rises about 3:00 A.M. and is nearly due east of Jupiter just before dawn. At +13.8 magnitude, Pluto is a difficult object to observe. A telescope with at least an eight-inch lens or mirror is needed, as well as some very good star charts. For beginners trying to locate the ninth planet, the maps supplied in the *Observer's Handbook,* published by the Royal Astronomical Society of Canada (University of Toronto Press), are recommended.

The **Moon** is full on the 8th at 7:37 A.M., EST; reaches last quarter on the 14th at 11:01 P.M. EST; is new on the 22d at 1:27 P.M., EST; and reaches first quarter on the 30th at 6:20 P.M., EST.

The Quadrantid meteor shower (named for a constellation, Quadrans Muralis, that is no longer recognized) peaks on the night of the 3d-4th, also the night of Mars' closest approach to the earth. One of the year's best showers, the radiant of this shower is located near the constellations Bootes, Draco, and Hercules, rising in the northeast about midnight. Unfortunately, the moon is up until well after midnight. But the shower is certainly worth an attempt—it has been known to reach rates of 110 visible meteors per hour. The Quadrantids are characteristically blue in color, with fine white or silver long-spreading trails. The parent comet of the Quadrantids is unknown.

Gail S. Cleere writes on popular astronomy and is a founding member of the International Dark Sky Association, an organization dedicated to preserving the skies for astronomy.

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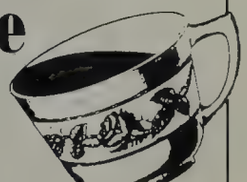
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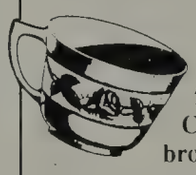
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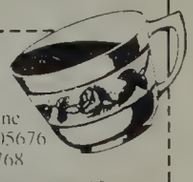
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Flagpole Knob, Virginia

by Robert H. Mohlenbrock

When Bob Glasgow, the wildlife biologist with Virginia's George Washington National Forest, alerted me to the discovery of a virgin stand of eastern hemlocks on Shenandoah Mountain, he promised me that it looked like the "Redwoods of the East." A few days later I met Bob and forest botanist Steve Croy at the forest headquarters in Harrisonburg and with eager anticipation set out on a twenty-two-mile drive, traveling through Mennonite country and passing huge turkey farms. Our first destination was 4,397-foot Reddish Knob in the middle of Shenandoah Mountain, where we could get an overview of the entire region.

Shenandoah Mountain is one of a series of northeast- to southwest-trending mountains that are separated from each other by broad valleys of farmland. Across the valley to the east of Shenandoah Mountain is the northern section of the Blue Ridge Mountains and its famed Shenandoah National Park and Skyline Drive. The mountain to the west of Shenandoah Mountain is West Virginia's Cheat Mountain, with its highest point, Spruce Knob, topping out at 4,860 feet. All of these mountains, with their lush vegetation and rounded ridges, are part of the Appalachian system, formed several hundred million years ago.

As we approached Reddish Knob, we noticed a few quaking aspens and paper birches, uncommon trees for this area, in the dry, rocky woods. At one inviting spot we stopped and walked into a parklike forest whose understory had been kept clear by lightning fires. Pennsylvania sedge formed a grasslike carpet over much of the ground, occasionally punctuated by painted trillium, cucumber root, fly poison, and false lily of the valley, all spring-flowering members of the lily family. W paused to examine a low, craggy, san stone outcrop and found the succule blue-leaved sedum and the related wh alumroot and Virginia saxifrage. T wood rat, a pack rat, builds its nest alo these types of rocky ledges. Lumbering wood rat territory has reduced the numb of the animals nationwide.

After driving on to the summit, w viewed the rounded crest of the slight lower Little Bald Knob five miles to t south. As its name implies, Little Ba Knob, like the other higher knobs in t area, is devoid of tall trees. Instead, scra gly bear oaks surround a summit of Pen sylvania sedge. Little Bald Knob has t added significance of being at the southe end of the range of the Cow Knob sal mander. Recognized as a species only fi years ago, this secretive amphibian liv in a twenty-four-mile-long by one-mil wide zone along the crest of Shenando Mountain. The animal has a black-an white speckled body and large round eye Its flat snout helps it burrow under roc and stones.

The Cow Knob salamander apparent developed as a distinct species because was isolated on Shenandoah Mountain f thousands of years. The forests on th mountain summits, inaccessible for timb harvesting, provide its ideal living cond tions. Similar but different species of sal manders live in isolation on the adjace mountains. The Cheat Mountain salama der lives to the west, while the Shena doah salamander lives on the Blue Ridg range to the east.

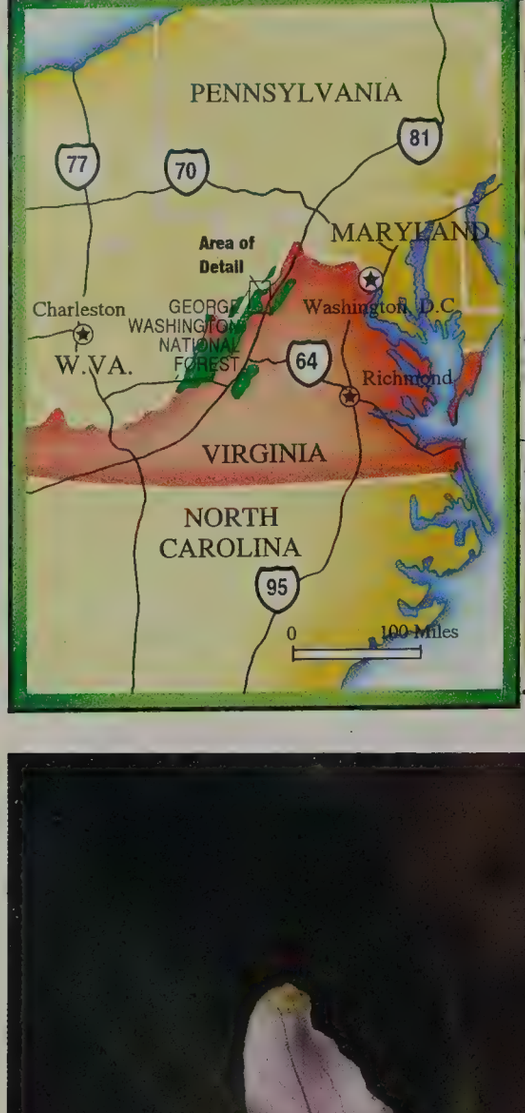
North from Reddish Knob we followe the Forest Service road toward Flagpo Knob, stopping again to explore a Pen sylvania sedge opening surrounded b gnarly, lichen-covered hawthorns, Tab Mountain pines, and an attractive shru

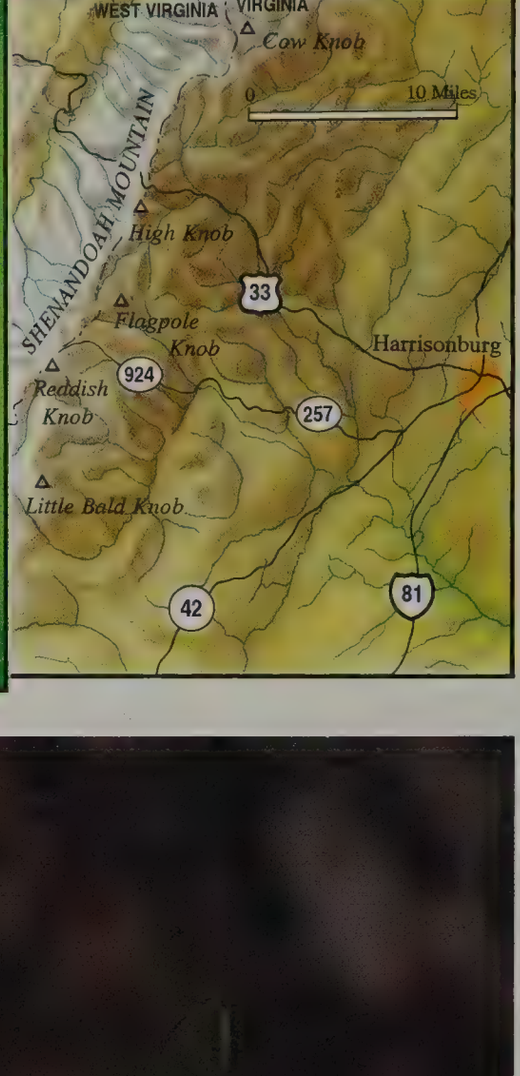


The Cow Knob salamander, above, is confined to a zone twenty-four miles long and one mile wide on the crest of Shenandoah Mountain. Opposite page: Eastern hemlocks grow undisturbed northwest of Flagpole Knob.
Rob and Melissa Simpson



Joe LeMonnier







Dwarf Virginia trillium grows only on Shenandoah Mountain.
Rob and Melissa Simpson

Flagpole Knob

For visitor information write:
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known as the many-flowered pieris. T
pieris, a member of the heath family, is
full of white, bell-shaped blossoms in m
May that the leaves are nearly hidde
This sedge opening and one other, also
Shenandoah Mountain, are the only plac
in the world where the dwarf Virginia t
lium grows. This plant's nearest relati
lives in the Coastal Plain.

From a roadside pullout near Flagpo
Knob, we blazed our way down the we
ern side of Shenandoah Mountain in t
direction of a ravine formed by Skidmo
Creek. Because it had rained hard t
evening before, we had to descend slow
over the treacherous jumble of slippe
rocks. Soon we found ourselves in a par
like forest that had rarely been disturb
by humans. Above a nearly continuo
thicket of fetterbush rose the giant easte
hemlocks. The grove was like a redwo
forest on a smaller scale; the hemloc
grew straight and tall, with several of t
larger ones approaching a girth of thr
and a half feet at shoulder height. Sever
species of birds use the forest for nestin
including the red-breasted nuthatch, t
brown creeper, and the red crossbill.

These trees had escaped the mass lu
bering that has destroyed the native fores
of the East and soon threatens to consur
all the old-growth forests of the West. T
prevent the loss of such natural commu
ties that remain in the George Washingt
National Forest, Bob Glasgow and his co
leagues have joined with the Virginia He
itage Program to identify the best are
and set them aside as reserves. As Gla
gow commented, this approach not on
protects biodiversity but also enhances t
public perception of the George Washin
ton National Forest and relieves logge
from any concern that they might inadve
tently wipe out important populations
plants or animals.

*Robert H. Mohlenbrock, professor emer
tus of plant biology at Southern Illino
University, Carbondale, explores the bi
logical and geological highlights of t
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What, Me Quarry?

You can never have too many 1938 Allis Chalmers WCs

by Roger L. Welsch

I changed my mind the moment we came over the hill and I caught sight of Stromp's Dump. Maybe it was a flash of insight, or maybe I'm just getting older, but what I saw in this junkyard was not the same thing I used to see when I saw a junkyard—rural blight, pollution, ugliness, junk.

For one thing, at Stromp's Dump there is a double row of ancient, sheet-metal combines flanking the entrance to the place, stretching off to the east and west almost as far as you can see. It reminds me of a Maya monument. I'll bet that on the vernal and autumnal equinoxes, if you stand in just the right place, maybe over there by that rusting steam traction engine, the sun rises right between that double row of combines, and some day archeologists will write about it.

We drove slowly into Jim Stromp's yard. Jim wasn't home, but we had already been told by several dozen other people, who drive hours from all directions to Stromp's for tractor parts, that we could go ahead and salvage whatever parts we needed and then just check with him when we left. So we—my daughter Antonia, my pal Woodrow, and I—drove across the yard and through the big iron gate that leads to...The Tractor Yard.

My 1938 Allis Chalmers WC surprises me a lot—nearly every time I turn the crank, in fact. It starts when it has every reason not to, it pulls better than it should at its age, it runs with almost no care, and it uses next to no gas or oil. Then, earlier this year, I got another 1938 Allis Chalmers WC (as I told my wife, Linda, you can never have too many 1938 Allis Chalmers WCs), and I found myself looking for brake parts.

Where do you get parts for a 1938 Allis Chalmers WC, I wondered? First, Mel up at the Mobil station in town gave me a catalog because, it turns out, you can buy almost any part you need for almost any tractor ever made, including a 1938 Allis Chalmers WC, new or rebuilt, through the mail. I suppose that should have been obvious to me, but like a lot of things that should be obvious to me, it wasn't: tractors last forever and so there are a lot of 1938 Allis Chalmers WC tractors still running out there and a lot of them need parts, and there are people who take apart tractors that don't run and make those parts available for people like me who need parts.

Mel's revelation opened a new world for me, but it got better—a lot better. Woodrow suggested that we could find parts even cheaper at Stromp's Dump, and have more fun at it. He said we could get things like entire front ends that we'd sure never get through the mail, and from the gleam in his eye, I knew he was telling the truth. So we ran up to Stromp's Dump, a little more than an hour away from my farm, and a whole new galaxy opened.

We drove through Stromp's gate and a scene for all the world like Oz or Wonderland stretched before us. I gasped. "Wow, Dad," Antonia sputtered. "There's a green hill and a red hill and an orange hill and..." And she was right, because the hill immediately to our left was covered w hundreds of carcasses of orange A Chalmers tractors, and the hill directly fore us was blanketed with the remnant green John Deeres. There were red In nationals, and far away, nearly at the h zon, Cases, Olivers, Fergusons, a Whites and...well, all in all, it was amazing sight: acres and acres of tract in various stages of wreckage.

Woodrow, who had been to Strom before, took a moment to enjoy amazement and then said, "Let's see y list." I handed him the paper listing parts I hoped to find—a belt pulley, a fr end, two full sets of brake parts, an filler cap, that sort of thing—and grabb his bucket of tools, he set off wadi through the sea of cannibalized WCs. A tonia and I grabbed our bucket of tools a set off in the opposite direction acr Allis Chalmers Ravine.

The day was cold and cloudy, and worked with some haste, hoping to get parts and return to the warmth Woodrow's truck as quickly as possib As we pulled, twisted, hammered, a



ed, other drivers steered their pickup cks slowly through the yard and pped near likely sources of parts for atever tractor they were in hopes of fix-. I heard occasional snippets of conver-ion over the wind, the sounds of steel ls on steel parts, the unmistakable eech of a crescent wrench burring the ners of a bolt and sliding off, muffled rses, and the sound of sucking on aped knuckles.

The Greenies on John Deere Hill spoke their quests—a wide front end, fly-eels, and front steel—and we Orangies Allis Chalmers Ravine combed through wreckage for ours—a magneto, a fuel diment bulb, the bottom half of an air aner. Occasionally we looked across utral ground at one another, grunted a eeting, maybe borrowed a tool, but hile it was clear that we were all there for same purpose (harvesting parts), we ere as alien to each other as ancient wnee and Lakota miners working thin sight of each other at flint quarries.

That was it! That was what changed my derstanding of junkyards. I had always ought of places like Stromp's as terrible aces, ugly concentrations of litter and in, but now for the first time I saw that is was a quarry—a tractor parts quarry. e were all of us—Greenies, Orangies, d Yellowies—engaged in a recycling ocess, salvaging entire vehicles, piece piece, scavenging the abandoned to scue the still serviceable. Like Native mericans at flint quarries, we were shar-g a kind of ad hoc truce with members of her tribes at work in the same quarry.

Native American Quarriers: "Boy, look those ugly shagnasties over there hack-g away at the worst flint in the quarry; on't those bozos ever learn how to make cent weapons? Whatever they're eating nells like it should have been buried a ng time ago. Uh oh, here comes one of m. What? You want to trade some of our elk pemmican for an antler flaker? Yeah, that sounds fair enough. Here, try a little of this dried chokecherry too. What's that brown flint look like over there? Worth digging?"

Us: "Woodrow, look at that. Those dummies are trying to take off a steering wheel with pliers—as if it made any sense to dink around with John Deeres to begin with. Is he trying to adjust that carburetor with a hammer, or what? Uh oh, here comes one of 'em. You want some penetrating oil? Yeah, sure. Here you go. Help yourself. Blackberry brandy. Sounds good. Will it help break those bolts loose? Hmmm, I'll bet. Here, try this socket on that steering wheel. Didn't happen to see the front spindle off'n a square-nose Allis WC over there, did you?"

Different worlds, but for the moment, today, here at Stromp's, we're staying cool and avoiding discussions of religion, politics, and farm implement lines.

That afternoon, as we drove out of Stromp's with our Allis parts, I wondered if we weren't missing something by leaving so early in the day. I imagined aloud if maybe at night there aren't little campfires scattered around Stromp's Dump, perhaps shadowy figures huddled over them, scouring parts with wire brushes or conversing in muffled tones about a nearly virginal sector gear needing only one more pin pounded out before it can be removed and taken home. Maybe secret songs are sung, inviting the blessings of gods that protect or vex swathers and combines. On appropriate days, are there arcane rituals initiating young apprentices into the secrets of the Massey-Harris clutch assembly, sacrifices to the spirits of internal combustion?

"What do you think?" I asked Antonia and Woodrow.

"Huh?" said Woodrow.

"Let's eat," said Antonia.

Folklorist Roger L. Welsch lives on a tree farm in Dannebrog, Nebraska.

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Coming In on a Wing and an Ear

uilt-in sonar detector gives some praying mantises an edge in aerial combat

David Yager and Mike May

. male praying mantis flies through the it, searching the breeze for chemical als that could lead him to a receptive e. Meandering at four miles per hour, mantis suddenly hears ultrasonic s—the sonar signals of a hungry bat ting nearby. In an instant, the bat de- s the mantis, and the ultrasonic pulses ie faster and louder. Now the swift and cious bat closes for the kill. This hly maneuverable predator is fifty es heavier and flies two or three times faster than the mantis. Can the seemingly helpless insect overcome these odds and escape?

Historically, zoologists might have expected the mantis to use its extraordinary vision to help it evade the bat, even in situations with little light. The mantis's huge eyes and attentive demeanor are reflected in its name: to the ancient Greeks, *mantis* denoted one who saw the future, a prophet or soothsayer. By habit, the mantis is a daytime hunter at the top of the invertebrate food chain. Exceptional vision allows it to seize prey, flies and other insects, with precision.



green, long-winged male praying mantis mates with a larger, ort-winged female, left. A threatened mantis, above, raises its relegs and arches its abdomen in a menacing display.

Cheeseman

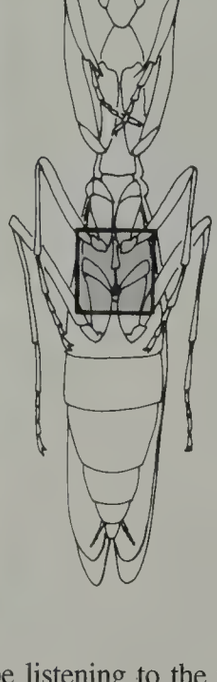
Although many insects can hear, hearing appeared to be absent in the mantis. Mantises do not produce audible sounds (beyond an occasional soft "whoosh" when handled) and were never seen responding to sounds. Furthermore, experts had found no ears like the ones that are so prominent in crickets, katydids, grasshoppers, and moths. Scientists concluded reasonably that the mantis was deaf.

Nevertheless, the thought that mantises might be able to hear resurfaced periodically among mantis aficionados and recently prompted a new set of experiments: if the mantis could hear, sound-related activity in the central nervous system could easily be detected with tiny wires placed inside the animal. These experiments showed conclusively that mantises can hear. When sounds were played, cells within the insect's nervous system burst into activity. This meant that the mantis has ears. But where?

The mantis's auditory system is seemingly unique in the animal kingdom. The mantis is an "auditory cyclops"—it has a single ear in the middle of its body on the ventral side, or underside. All other animals known to hear have two ears located on the sides of the body or the head. And the mantis's ear does not look like an ear at all. It is a deep slit, about one millimeter long, with two knobs of hard cuticle at the front end. There are two eardrums inside the slit facing each other from opposite walls. Unlike other insect eardrums, which generally look like membranous drumheads, those of the mantis are a thin, stiff cuticle in a teardrop shape. Neuro-



Located on the mantis's belly, within box below, the single ear is a slit containing two eardrums and protected by knobs of cuticle, at left, magnified 30 times. Eared mantises can hear ultrasound, but they cannot determine the direction of the source.



physiological and behavioral experiments showed that the two eardrums act together as a unit. These experiments also suggested that having an ear in a deep slit may increase sensitivity to sound of certain frequencies. A highly visual insect, the mantis also possesses a sensitive auditory system. What role does hearing play in its everyday life?

Assuming mantises hear best the sounds most relevant to their lives, we tested which frequencies of sound most stimulated their central nervous systems. Neurophysiological audiograms showed that the mantis does not hear sounds as we do. The vast majority of animals, including humans and insects, use and hear frequencies below 10 kilohertz. (We cannot even hear sounds above 15 to 20 kilohertz.) For the mantis, by contrast, the best hearing lies in the ultrasonic range between 25 and 60 kilohertz and up to 100 kilohertz in some species.

These results suggested three possible functions for hearing in mantises. They eat some insects, such as katydids, that produce nocturnal, ultrasonic songs. Maybe at night the mantis locates its prey by sound rather than by the daytime visual strategy. Or, it may use sound to communicate with other mantises during courtship when the small, slight male has to convince the larger, hungry, and highly predatory female that he is something other than a meal. Finally, mantises may be listening to the most common animal source of ultrasound—hunting bats. Some species of moths and the green lacewing, for instance, are known to listen for bats in order to evade capture.

The structure of an animal's auditory system to a large extent determines its hearing capabilities. The separation between the two ears allows an animal to pinpoint the location of the sound source—a critically important capability in day-to-day life—by comparing the loudness or the timing of the signal arriving at each ear. The mantis, however, has only one centrally located ear, and both behavioral and physiological experiments showed that this insect cannot locate the source of a sound. The mantis certainly could not locate prey effectively or efficiently by using sound cues. Nevertheless, nondirectional hearing could still be useful, though perhaps not optimal, in either courtship or bat avoidance.

The most decisive clue to the function of mantis hearing came from months spent studying dried specimens in the quiet, dusty research rooms of museums. Approximately 2,000 species of mantises are known. In contrast to temperate zones where mantis fauna consists of fewer than 20 species, tropical regions such as eastern Africa boast up to 350 species that range in size from less than half an inch to more than five inches. Do these different mantises hear differently? The results of the museum work on the ear anatomy of mo than 1,000 species of mantises were corr lated with physiological tests on 35 sp cies of living mantises. The comparis showed that not all mantises have th same auditory capabilities. While abo 60 percent of the mantises examined hav the type of ear described above and hea ultrasound, some are deaf. Most of thes earless mantises unexpectedly have an other attribute in common—their wing are too short for flight. In other words, if mantis has short wings or no wings at al it also is earless and deaf. This correlatio is so strong that almost a third of all man

Photographs by David Yager and Mike May

The mantis usually flies with its legs tucked in and abdomen flat. When it detects the ultrasonic signals of a hunting bat, the mantis stretches out its forelegs and arcs its abdomen, below, which may cause the wings to stall. The insect then veers and dives away from the predator. A strobe photograph, left, reveals the spiral flight path of one mantis exposed to ultrasound.



species show auditory sexual dimor-
ism—the males have long wings and
ar ultrasound, but the females of the
ne species have short wings and cannot
ar. A mantis's ability to hear ultrasound
ust be related to flight. That led us to ex-
ine mantis flight and the insect's inter-
ion with bats.

Our exploration into mantis flight
rted rather simply. We fastened a mantis
a thin wire and suspended it in the gen-
wind stream from a fan; essentially, we
ced the mantis on an aerial treadmill.
ith just a bit of coaxing, the mantis
read its wings and flew, assuming a streamlined posture with its legs tucked neatly against its body. But when we broadcast a batlike burst of ultrasound, the mantis snapped into action in less than a tenth of a second: it thrust its front legs forward and curled its abdomen above its back. Looking more closely, we noted that the mantis also turned its head and beat its wings in larger but slower strokes. The mantis reacted strongly to signals that resembled the echolocation cries of a hunting bat.

This provoked a bigger question: What happens when a freely flying mantis hears ultrasound? To keep our valuable subjects from flying away, we first sought this answer in a large room, about half the size of a baseball diamond. At one end of the room, we hung an enormous drape of black paper as a photographic backdrop. At the other end, we positioned a camera and strobe light to record stop-action photographs. We "shot" at the freely flying mantis with a "batgun"—an ultrasonic speaker mounted on a rifle stock. Between the drape and the camera, we taped the floor at three-foot intervals. The room acquired the appearance of a scientific playing field awaiting game day.

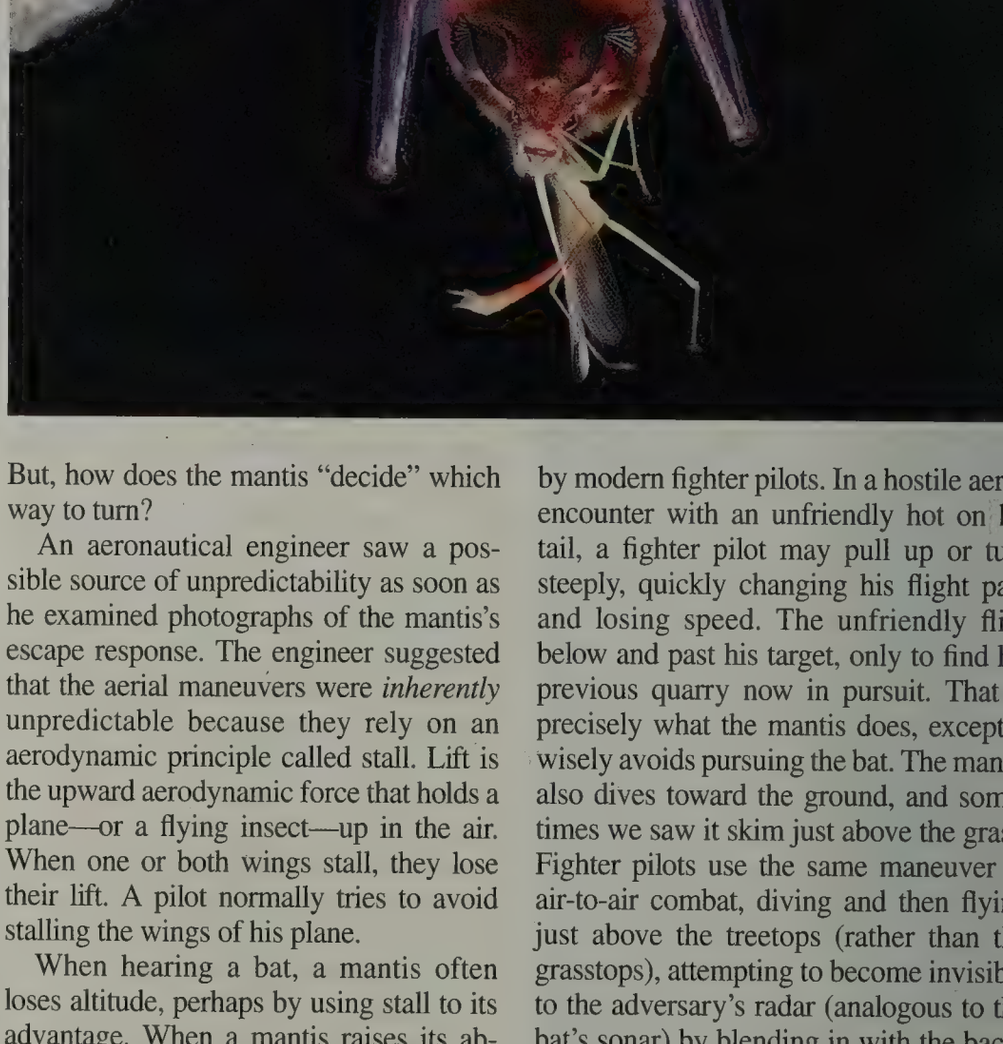
We then began launching mantises into the air one at a time, hoping they would cruise into camera range. One mantis after another flew over, under, or away from the camera. Finally, a mantis set its course past the camera. We turned on the strobe light, opened the camera's shutter, and "shot" the mantis with ultrasound. In less than two-tenths of a second, the mantis twisted into a steep, spiral dive and plunged to the floor, safe from the simulated bat attack.

After many weeks of work, the flying mantises told a story. When ten yards or more away from the batgun, where the ultrasound was weak, the mantis usually ignored the ultrasound or, at most, made a simple, level turn. Sometimes the mantis turned away, but at other times, it turned toward the ultrasound (the single-eared mantis couldn't tell the difference). When the mantis flew closer to the source of the sound, the ultrasound was louder and the insect responded vigorously. In less than two-tenths of a second, it rose slightly upward before turning into a power dive that often doubled its flight speed. At times, the mantis shot through a loop before the dive. Or, it turned during the dive. Some mantises dove to the floor for a landing. Others pulled up short and skimmed above the surface. At the closest range, just a few yards from the batgun, the ultrasound propelled the mantis into a nearly vertical dive, and it often spiraled as it approached the floor. Thus, the mantis can assess the urgency of the threat and respond accordingly. Nearer and nearer to the "bat," its response becomes progressively more dramatic, more evasive.

The ultimate question remained: Could

J. C. Carton; Bruce Coleman

A Costa Rican bat consumes a mantis, below. Mantises without ears are easy victims for such nocturnal hunters. A predator in its own right, a mantis lurks in greenery, right, waiting for other insects on which to feed.
Brock Fenton



a mantis escape from a real bat hunting in the wild? To pursue this question, we traveled to Pinery Provincial Park in southwestern Ontario, a field site for bat biologist Brock Fenton and his colleagues at York University and a place where the hunting patterns of bats have been thoroughly studied. As a test site, we chose a parking lot near the edge of a forest where tall lights provided some illumination for the aerial encounters to follow.

These tests required a team. One member climbed to the top of a twelve-foot ladder. Perched above the parking lot, he gently launched a mantis into the dark night air. The mantis quickly opened its wings and flapped across the sky as several observers followed on foot beneath it. Suddenly, a bat (in these tests, the red bat, a common bat of eastern North America) appeared from the treetops and closed on the mantis at roughly fifteen miles per hour. With every observer rooting for it, the mantis quickly began a steep, spiral dive to the ground. For a few turns, the bat joined the spiral, but it pulled out before crashing into the ground and then flew off in search of easier prey. The mantis could escape from a hunting bat.

After more than 200 launches, we had observed eleven bat attacks on the mantis. In five of the bat attacks, the flying mantis used evasive maneuvers and avoided even a brush with the bat. In three other attacks, the mantis performed no noticeable evasive action and, in two of the cases, was captured or at least hit by the bat. But, we wondered, was it hearing the bat that gave the mantis the edge? We tried another species of mantis deaf to red bat cries. We saw three bat attacks on this species. The mantis never made a move to escape, and the bat invariably caught the mantis. In the end, we had seen six attacks in which the mantis failed to respond. The mantis lost five of those encounters. In the five cases when the mantis did respond to the bat, the mantis won and the bat flew away hungry.

The success of the evasion lies in the insect's unpredictability; the mantis sometimes turns to the right and sometimes to the left, regardless of the bat's position. But, how does the mantis "decide" which way to turn?

An aeronautical engineer saw a possible source of unpredictability as soon as he examined photographs of the mantis's escape response. The engineer suggested that the aerial maneuvers were *inherently* unpredictable because they rely on an aerodynamic principle called stall. Lift is the upward aerodynamic force that holds a plane—or a flying insect—up in the air. When one or both wings stall, they lose their lift. A pilot normally tries to avoid stalling the wings of his plane.

When hearing a bat, a mantis often loses altitude, perhaps by using stall to its advantage. When a mantis raises its abdomen in response to ultrasound, this move should make the front of its body lift up, causing the forewings to move to a steeper and steeper angle. At some angle, a forewing will stall, but each forewing is equally likely to stall first. If it is the right forewing, the mantis loses lift on the right side and then dives to the right. If it is the left forewing, the mantis dives to the left. Which forewing stalls first, however, is entirely unpredictable. So if the escape response does depend upon stall, it makes the entire flight path random.

Regardless of the exact mechanism, the mantis's escape response is a good evasive maneuver, one discovered independently by modern fighter pilots. In a hostile aer encounter with an unfriendly hot on tail, a fighter pilot may pull up or tu steeply, quickly changing his flight pa and losing speed. The unfriendly fli below and past his target, only to find previous quarry now in pursuit. That precisely what the mantis does, except wisely avoids pursuing the bat. The man also dives toward the ground, and som times we saw it skim just above the gra Fighter pilots use the same maneuver air-to-air combat, diving and then flyi just above the treetops (rather than t grasstops), attempting to become invisib to the adversary's radar (analogous to t bat's sonar) by blending in with the bac ground clutter.

When bats appeared some 60 milli years ago, they posed a serious threat nocturnally flying insects. In response, t praying mantis developed an unpr dictable evasion strategy—twisting left right into a spiral dive to the ground. T mantis, a creature limited to the compu ing power of just a few tens of thousan of nerve cells, thus thwarted its seeming more advanced mammalian predator, t bat. But limited or not, the mantis offers advanced lesson in aerial combat strat gies today used by fighter pilots flyi multimillion-dollar aircraft with the late tactical computer technology.





Maslennitsa, the snow queen, is lifted on poles by Kreshnevo women and set on fire. Masqueraders dressed as devils, cats, and goats dance to accordian music as she burns.

The Death of Winter

In remote eddies of Eurasia, villagers joyfully kill the old gods so Earth can be reborn

Text and photographs by Alexander S. Milovsky

For most of my professional life as a journalist, I have explored the nooks and crannies of my native land, the former Soviet Union, searching for survivals of the sacred in a supposedly secular country. When I found a nineteenth-century book on Russian folklore that described certain New Year's rites, I knew I would soon be traveling again. Its author, A. N. Afanasyev, had written, "The Slavs have an old custom of welcoming spring in the month of March and banishing Death, or Winter. They carry a straw effigy of Death out of the village and down to the river, then drown it or first burn it and throw the ashes into the water, because Winter dies in the burning rays of the spring Sun and the swift streams of thawed snow."

Long after Russia's conversion to Christianity in the tenth century A.D., many ancient traditions survived and were still fairly common during the last century. The original New Year's celebrations focused on Kolyada, the newborn sun. Local customs varied widely, but folklorists recorded that some common elements persisted: a ring of bonfires to show the luminary its path through the sky and masked figures to frighten off evil spirits that might obstruct the solar journey. In many villages, poles with disks on top and fried round pancakes symbolized the sun.

After more than 750 years of government efforts to wipe out such "archaic" customs, festivals connected with the death of winter no longer existed, even in the remote villages—at least so I was told by Russian ethnologists. During the mid-1980s, however, I set out for the far corners of the USSR to see for myself what, if anything, remained of the old ways.

My first trip was to the rural village of Kreshnevo, in the Vesegonsky District of the Tver Region. Although it is only 250 miles north of Moscow, the deep forest in which the village is situated remains home to lynxes and bears. Following a custom that may stretch back thousands of years, the villagers still create gigantic dolls of the winter spirits, which they "kill" in a ritual bonfire.

I visited Anna Sharonova, an aging peasant woman, whose century-old log house was cluttered with a jumble of horned masks, fake mustaches and noses, bits of black fur, colored paper, and balls of thread. Beneath the bright bare lamp, she and her friends and neighbors were busily cutting and sewing. "We are making the carnival costumes," she explained. "It's time to hail the spring, even though the snow is knee-deep."

The next morning, four large sleighs entered the village, drawn by horses wearing bright ribbons in their manes and jingling bells on their traces. Singing at the top of their lungs, the sleighs' passengers—gaily costumed young men—raced their horses to the nearby town of Vesegonsk, where the "pancake week" bazaar was already in progress. Accordian music was heard everywhere, and jester-clowns entertained crowds in the market square. Festivities continued all day, culminating in the highlight of the



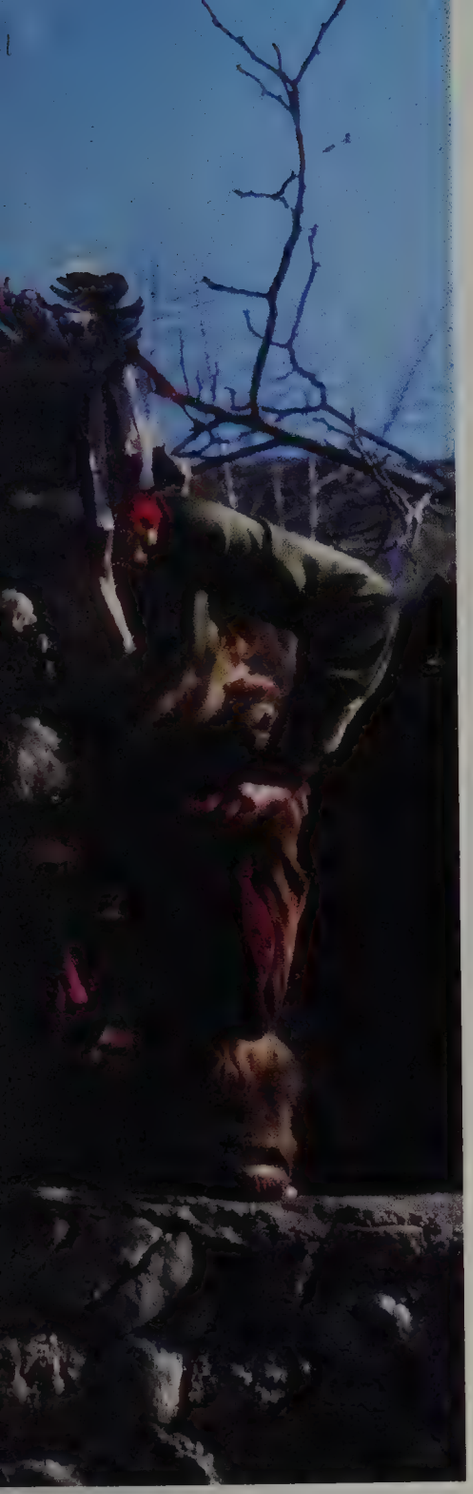


week: the execution of Maslennitsa, the snow queen.

At sunset, her larger-than-life effigy, resplendent in an orange-gold dress, was driven on a sleigh down the main village street as a crowd followed. Amid laughter, horseplay, and song, she was escorted to the riverbank, where firewood had been stacked. The dry logs blazed swiftly in the dark with an orange flame that resembled the orange of her dress. When the bonfire was high, the doll was raised on poles and placed within it. Instantly, the flames enveloped her paper dress, her straw hair, and her body. The Kreshnevo women, it seemed to me, were sorry to consign to the flames the handsome doll they had so assiduously labored over—but that was her fate from the beginning. Milk was poured on the fire, signifying that the weeks of milk and cheese were over, for Lent had begun. Anticipating its imminent defeat, I thought, Winter shed large tears of moist snowflakes that hissed as they turned to steam on the birchwood embers.

A year later, at the end of January, I trudged through deep snow to the Dagestan village of Shayitly, perched among the Caucasus Mountains, in Russia's southwest, to join the winter festival of Igby. Along the way, I followed canine tracks and came upon the bloody site where wolves had recently taken a deer. When I reached Shayitly late at night, exhausted, I found the villagers busily preparing for the holiday. Skins and masks were being refurbished, and the ritual *igi* bread was being baked, all in preparation for the first appearance of sunshine upon the mountainside facing the village—an event that is considered the beginning of the end of winter.

I stayed in the house of the forest warden, who told me that the *botsi,* or magical "wolves," would descend from the hills the next morning. Shortly after dawn, with the whole village gathered i the square, I sat and watched the first light illuminate the mountainside and heard the exultant cries of young boys. They had spotted two strange figures coming toward the town. Suddenly, two more *botsi* appeared. Festooned with colored ribbons, these "wolf spirits" wer dressed in sheepskins and tall, conical f hats attached to masks. More of them advanced on the town square from all sides, waving long wooden swords, bullying people, and pushing some into



Mysterious mud-bedaubed marauders, the beriki *rush around the Georgian countryside, brazenly demanding tribute.*

e snow. Unrecognizable to their ighbors, they remained silent so as not reveal their identities. Later, they went om house to house collecting tributes of usty *igi* breads on their swords.

Toward late afternoon, the main aracter of the festival, Quidili, made his ppearance by ambling down the same ountainside. He was a tall, shaggy eature, with a large head, expressive lging eyes, and an enormous pink outh with shining copper teeth. His ant wooden jaw repeatedly opened and acked closed. Villagers and *botsi* alike ere respectful, yet bolder youngsters entured to tug at his garb or jab a ooden stick into his giant mouth. No ne could tell me the meaning of uidili's name or the story of his origin. et all agreed that he was the supervisor of this crucial day after which spring began, and that he had to be decapitated if they wanted warm days to follow.

Ascending an ice platform, the mysterious visitor was greeted by the village schoolmaster, who announced that "this day the most just Quidili has come down from the hill to praise all hard-working people and to denounce idlers, spongers, drunks, and cheats." After the spirit figure had solemnly nodded agreement, the best shepherds, dairymaids, pupils, and dancers were awarded an *igi* bread. Then the village miscreants were named, and the *botsi* dragged them to the riverside, where they were dunked in ice-cold water.

After justice had been meted out, Quidili wished the villagers peace, prosperity, and a good harvest and then followed the *botsi* to the local river bridge. There he calmly lay down and was "decapitated" by a village elder wielding a violet-red sword, leaving a puddle of make-believe blood in the snow. I remembered the bloodstained snow I'd seen the day before; despite relentless persecution, both the real wolves and the ritual wolves had managed to survive in these woods. Several *botsi* put the "corpse" on a stretcher and carried it away. Merriment returned quickly, and the wolves shed their costumes out of sight of the crowd and rejoined their neighbors amidst the celebrations.

In late February, in the Kakhetian village of Patar Chailuri on the Georgian side of the Caucasus Mountains, I witnessed a similar drama: the Berikaoba festival. Here the traditional masqueraders are known as *beriki:* four mysterious, whip-wielding characters dressed in skins and colored cloth. They cover their faces with huge, black sheepskin masks that have turkey feather "horns" and shreds of goat wool for mustaches, eyebrows, and beard. Along with them travels a wild boar personage, covered in white pigskin, with a hideous tusked mouth; a masked drummer; and a donkey and driver.

Quidili, the shaggy giant who appears at midwinter in the Caucasus Mountains, is sacrificed.



Rowdy and brazen, this bizarre band smeared themselves with mud and rushed around the village creating pandemonium. Their goatskin masks and sheepskin capes, ancient symbols of fertility and fecundity, are welcome harbingers of spring. Although they "invaded" every house, shrieking and demanding gifts from each family, their hosts gladly handed over bread, fruit, eggs, cheese, and wine. Those householders who refused to pay tribute were punished by having mud daubed on their faces.

Eventually, the *beriki* rushed into the village square, where the crowd had been entertained by wrestling matches, and began to enact an annual drama. Circling the tall pole erected there, they began to imitate the sowing of corn by dragging the handles of their whips through the earth. At this point, the pigman began "ruining" the field and was chased and whipped by the *beriki* until they "killed" him. Finally, all retired to an elder's house, where they shed their costumes and consumed the day's haul. Villagers did not begrudge them their booty, for they believe that the merrier the *beriki* party, the richer the harvest will be.

The following year, in search of still more celebrations of the death of winter, I

Playing the king, an Orubad youth gives imperious orders during an ancient Azerbaijan festival.



In northern Moldova, Katjusha, the revered goddess of the Malanka festival, is revealed as a male prankster.



traveled to northern Moldova to visit the indigenous mountain cultures of the Carpathians. I arrived at Klokushna at the time of their New Year's celebration, when pranksters in black sheepskin masks stopped my car as I entered the village. They demanded a toll to enter; we eventually agreed upon some of my photographs. The impudent supernatural characters are called *moshi,* the protectors of the festival. Once inside Klokushna, I found that the traditional mummer's play called Malanka was being performed at the door of every house, after which everyone exchanged best wishes for the New Year.

Here the motif of winter's death and the birth of spring is expressed by the murder and resurrection of a beautiful girl named Katjusha. She wears a face veil, disguising the fact that the lovely young woman is actually played by a young man. Katjusha stands in the center of a circle of twelve warrior kings all decked out in tall hats adorned with colorful ribbons and artificial flowers, silver foil belts, magnificent epaulets, and swords. When one makes a pass at her, she rebuffs him bluntly; he flies into a rage and murders her. When the crowd rebukes the king for his foul deed, the guiltless girl returns to life. One of the *moshi* then goads the onlookers into contributing gifts for the victim, which he gathers into a bag. At this point, Katjusha asks him for a cigarette from among the goodies; when she puts aside her veil to light it, the audience gasps in mock surprise as they glimpse the trickster's masculine face.

My last stop was in the old Azerbaijan town of Ordubad, in the Muslim area south of Georgia and above Iran, where another ancient substitution drama is still played out. These villagers celebrate the displacement of winter by enacting the replacement of their *khan* (king) with a simple youth for the duration of the festival. On their holiday of *Khan-khan ojunu* (playing the ruler), the traditional drama takes place in the medieval town square, near a mosque and under a gigantic chinar tree.

Prior to ascending his throne beneath the ancient tree, the khan and his retinue parade through the town, followed by frolicking children and accompanied by musicians. When the khan finally mounts his seat of power, people try to distract him with riddles and loaded questions. However, he remains regally aloof, answering all questions through his vizier and advisers, for he may not smile or break character.

Supplicants ask that their neighbors be severely punished for supposed crimes such as chicken stealing. "Chop his head off," the vizier says, relaying the khan's harsh sentence. But an advocate for the alleged poultry pilferer manages to soften the penalty, which is reduced to singing a song and dancing. Soon, everyone is doing the same. When my turn comes, I ask a royal favor. "Most illustrious and just Khan, please permit me to photograph you and your brilliant retinue." An unsmiling twitch of the eyebrows, a slight nod to the executioner, and the latter raises his whip, but I did get my pictures.

Like the king, the snow queen, Quidili, and Winter itself, the ancient connections of Slavic, Carpathian, and Caucasian countryfolk with the land's cycle are not dead at all, but are reborn every year. □




It's time for a change to Gallo.
THE VINEYARDS OF
Shellfish bouillabaisse with cilantro.
©E. & J. Gallo Winery, Modesto, CA.


Ernest & Julio Gallo
Chardonnay

Immature spotted hyenas lounge about the clan's communal den.
Joe McDonald



Growing Up in the Clan

In spotted hyena society, nothing beats a mother's influence

by Laura Smale and Kay E. Holekamp



Sleepy and cramped in our four-wheel-drive vehicle, we watch the rising sun paint the morning clouds with streaks of red and gold. A few yards away from us, seven adult hyenas, all females, doze peacefully near their clan's communal den. As the females rest, nine cubs are busily occupied around them. Two small cubs, whose first spots are just beginning to appear through their black infant coats, are nursing. Four older cubs sniff a leopard tortoise that has discreetly withdrawn into its shell. Two play tug of war with a vulture feather at the den entrance, while another quietly chews on a gazelle horn.

This tranquil dawn scene in Kenya's Masai Mara National Reserve is shattered suddenly as all the adult females leap to their feet and stare intently toward the west. Their abrupt movements send the smaller cubs dashing into the den hole. Now, from behind the bushes, the object of their attention appears. It is another adult female, known to us as Cochise, and in her massive jaws, she is gently holding a tiny black hyena cub.

The baby swings limply as Cochise approaches. As the adult females rush toward her, Cochise sets her black cub on the ground and crouches over it protectively. The other hyenas, their manes and tails bristling with excitement, then surround Cochise, sniff her, and groan over the unfamiliar infant. With her forelegs bent back beneath her body and her baby cowering under her, Cochise crawls toward the den hole, snapping at a youngster that pokes with excessive zeal at her offspring.

When she reaches the den, her cub scuttles out from under her and vanishes into the hole, undoubtedly overwhelmed by its sudden arrival at this unfamiliar place occupied by so many strangers. Almost immediately, Cochise leaves the area; returning twenty minutes later with another tiny cub, she once again creates an uproar of excitement and curiosity. Only when the other hyenas calm down does Cochise call her two cubs out of the den with a gentle groan and begin to nurse them.

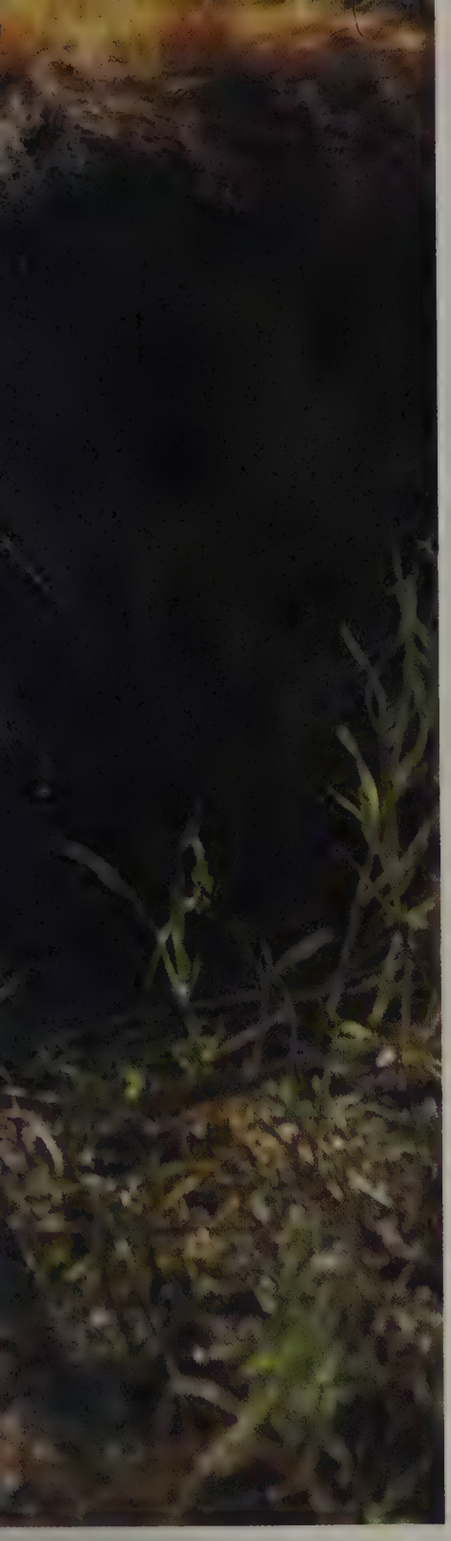
From our vehicle, we have been videotaping the arrival of these cubs, which we name Sioux (the first arrival) and Cheyenne. Videotaping is one of the techniques we have been using for the past four and a half years in an effort to understand the development of behavior patterns that shape the complex social system of spotted hyenas. Our fieldwork, conducted in collaboration with Laurence Frank, has focused on the clan to which Sioux and Cheyenne have just been introduced. This tightknit group of some sixty-four hyenas includes twenty-one adult females and their offspring and twelve adult males. All males over the age of five are immigrants from other clans, for while female spotted hyenas generally spend their entire lives in the same clan, males emigrate when they are between two and five years old.

The early morning events we have just witnessed represent a major turning point in the lives of these month-old cubs, which until now have spent all their short lives at the secluded den where they were born. There, their social world was small and simple, consisting of just their mother and themselves. In the weeks and months to come, we will watch closely as the little cubs progress through the various stages of hyena development and become integrated into the clan.

Spotted hyenas are gregarious carnivores found in many different types of sub-Saharan habitats, including deserts, forests, savannas, and beaches. They live in highly structured clans, in which each



David Madison; Bruce Coleman, Inc.





Kay E. Holekamp

A female cub, left, known as Sioux to the authors, leans against her mother, Cochise, to take a nap, revealing malelike genitalia. A mother carries her four-week-old cub, below, to meet the rest of the clan at the communal den. As two cubs nurse, below left, the dominant one gets the best spot, snug against its mother's belly, forcing its sibling to reach around it.

Robert Caputo



member holds a social rank. A hyena's rank has a profound influence on many aspects of its life, the most important of which is its ability to compete for food. After running down a large antelope, for instance, spotted hyenas often feed in a frenzied free-for-all, each individual trying to get as much food for itself as possible, often by attacking its clanmates and attempting to drive them away from the carcass.

But even amid a ravenous mob of thirty hyenas feeding on a fresh kill, matters are not as chaotic as they might seem: each hyena only attacks clanmates ranked lower than itself. As with many other animals, the hyenas' social system is structured around a rigid linear dominance hierarchy. However, unlike hierarchies found in most other species, the social rank of a spotted hyena in its natal clan is strongly influenced by its mother's position in the hierarchy and not by its size or its fighting ability. The only other species in which "inheritance" of maternal rank has been documented are some Old World primates, such as baboons, vervets, and macaques. Another unusual feature of the hyenas' social hierarchy is that the adult females normally outrank all adult males.

As they grow up in the clan, young hyenas face the task of working their way into this complex social system, learning to defer to hyenas from higher-ranking matrilines and to challenge those from lower-ranking matrilines. Sioux and Cheyenne, for example, must establish rank relationships with each of the other sixty-four members of the clan. One of the goals of our research has been to find out when and how a small hyena cub forms these relationships, and how the process differs for young males and females.

Our days in the field generally include several hours around dawn and dusk sitting in a parked vehicle, from which we observe and record the hyenas' behavior. Paralleling our work is a series of ongoing studies of captive hyenas at the University of California at Berkeley, conducted by Stephen Glickman, Laurence Frank, and their collaborators. Our hope is that the studies of both the captive and free-living animals will reveal the relative influences of hormonal and social factors on the development of social behavior of spotted hyenas, starting at birth.

After a 110-day pregnancy, which may

Born to Kill

by Laurence G. Frank and Stephen E. Glickman

In wild spotted hyena society, the first few weeks of life are intensely private. The female gives birth, usually to twins, at the mouth of an abandoned aardvark burrow, and the newborns crawl into the underground system, where they are safe from predators. Even the mother is too large to enter. The cubs remain in this den for several weeks, only coming to the entrance to nurse.

One of us, Frank, first began studying spotted hyenas in Kenya in 1979. Throughout the early years of that fieldwork, a puzzle arose: zoo data showed clearly that most spotted hyena litters are born as twins, but in Kenya, by the time the mother moved her cubs from the natal burrow to the clan's communal den (generally the first chance for anyone to see the cubs), about half the litters had been reduced to a single cub.

Because some of the surviving infants appeared emaciated, their backs covered with small scabs and wounds, an early hypothesis was that some sort of mange might be killing off the others. Over the years, however, other observations complicated the issue: of the litters that did survive as twins, nearly all were brother–sister pairs. Why were there so few same-sex pairs? Could mange possibly be responsible for this sort of pattern?

Solving this puzzle required being there at the very beginning of hyena life. Fortunately, facilities at the University of California at Berkeley made this possible. In 1984, we established a captive colony of spotted hyenas to study the hormonal processes that produce the highly aggressive and extraordinarily masculine females for which this species is well known. (The female spotted hyena has an erectile clitoris the size and shape of the male's penis, through which she mates and gives birth, and a "pseudoscrotum" where the vulva should be.) In the course of our work on hormones, we have discovered that the spotted hyena's arrival in the world is not only a very private affair; it is also strikingly violent.

The spotted hyena's 110-day gestation period is substantially longer than that of other hyena species. As a result, infants are born at an advanced stage of development, with fully erupted front teeth, open eyes, and the ability to move around much more vigorously than other newborn carnivores. When our captive females began to breed in 1987, we were astounded to observe the consequences of this advanced development.

Our first twins were born to Di, our biggest female. The infants were delivered approximately one hour apart, and the mother licked off their amniotic sacs immediately. (In our Berkeley study, mother and offspring are kept together in one large pen; there is no underground den.) Within minutes of the second infant's birth, the firstborn attacked it, fastening its sharp front teeth into the skin of the younger cub's back and shaking violently, displaying the same "bite-shake" attack on the shoulders that adult hyenas use on one another.

In another litter, the first attack occurred even before the second cub was free of its amniotic sac. The second soon started to fight back, and intense fighting continued throughout the first two or three day
Our captive mothers often paid litt
tion; in the wild, of course, the figh
curs in the depth of the burrow, wh
cannot intervene. In both litters,
eventually emerged as dominant
other, and we soon realized that
had called mange was actually e
scarring on the back.

Once established, the dominan
tionship is stable, and fighting betw
lings decreases rapidly. What happ
depends on the sex of the cubs. W
cubs are of opposite sex, both usua
vive, although the dominant one
faster and always has precedence at

In the wild, however, when bo
borns are of the same sex, the figh
parently continues until one dies. Tw
born litters that we hand reared illus
process. The first litter consisted of
ters, Rabbit and Owl, which were al
week old when we found them at th
den outside the Mara Reserve. Rab
half the weight of Owl, extremely
ated, and close to death. She bore
badly infected wound on the shoul
result of Owl's incessant attacks. In
ond instance, we found Tumo and
pair of males, when they were two
days old. Talek, larger and dominan
refuse the bottle we offered until he
tacked his brother. In each hand-rea
the smaller twin did fine. In same-se
in the wild, however, we believe th
is ultimately due to starvation, as th
nant is able to prevent the subordina
leaving the den entrance to nurse
colony, in the absence of a burrow,
ling still becomes dominant, but bo
per, regardless of their sexes.

Our studies of hyena hormonal
ment, carried out in collaborati
Berkeley endocrinologist Paul Lic
shown that the period of siblicidal
coincides with a period in which in
both sexes produce high levels of an
(male hormones). The mascu
anatomy and behavior of female hy
pear to be the result of a complex pr
which androstenedione, a hormo
duced by the ovaries and normally a
sor to estrogen, is converted to test
in the placenta. The developing emb
bathed in exceptional quantities o
terone, and after birth, both male an
cubs continue to produce their ov
hormones. Testosterone has been as
with aggression in many species, an
well have a role in the evolution an
tenance of intense neonatal fighting
ted hyenas.

This sort of Cain and Abel aggr
well known among eagles and ma



A close look at the shoulder of the cub in the foreground reveals marks strongly suggesting an attack by its sibling.
Robert Caputo

ıg birds, such as herons, egrets, and
but among mammals, only domes-
are known to engage in neonatal
The ecological and evolutionary
ions that seem to explain bird sibli-
ich appears to be tied to variable
ources, do not explain the hyenas'
, for in the Masai Mara—where
ex twins regularly survive—food
ıot seem to be a limiting factor.
asic questions remain to be an-
Why is the fighting usually fatal
th infants are the same sex but not if
opposite sexes? What does the win-
that offsets the evolutionary cost of
ts closest relative? Why does the
olerate the loss of nearly 25 percent
productive output? Is there any way
r could manipulate the outcome of
ing in the den to influence the sex of
iving offspring?
vhy did neonatal fighting evolve in
place? One possible answer has to
the spotted hyena's transition from a
scavenger, like the world's two
isting hyena species, to a highly so-
mal. With the evolution of group
came the fierce feeding competi-
which spotted hyenas are famous.
these circumstances, any adapta-
uch as aggressiveness—that in-
a mother's ability to insure her cubs
o a share of the carcass would be
dvantageous. Natural selection for
ggression may have favored devel-
of prenatal androgens and also, as
oidable developmental side effect,
nized genitalia. Neonatal fighting
ll have been a similar side effect of
e process. Once early fighting be-
ıportant, however, traits required to
fights—mobility, pugnaciousness,
eth, and large size at birth—would
en selected for in their own right.
ever the answers to these questions,
n to win an often mortal battle at
s been a powerful evolutionary force
spotted hyena. It may also exact a
ost from the mother hyenas, who
ve birth to their large babies through
ually small organ, the penislike cli-
captivity, first-time mothers experi-
ry long labor and a high rate of birth
cations. This may help explain why,
ild, females often disappear, and are
ed dead, about the time they would
ıg birth for the first time. Stretching
ring of the clitoris during the first
ıowever, do insure that subsequent
re much easier for those females that
and go on to produce more of the
s' remarkably precocial infants,
first actions are not the least bit in-

occur during any season, a female spotted hyena gives birth to one or two coal black infants, each weighing about two pounds. In the wild, the female selects an isolated old aardvark den, sometimes modified by warthogs, in which to shelter her cubs. The natal den, like the communal den, has a narrow opening too small for an adult hyena to enter. These dens can either be short (about nine feet long) with a single entrance or extensive, mazelike structures with many entrances. In general, natal dens are smaller and simpler than communal dens.

We get our first look at the cubs when they emerge at about ten days of age. The wild-born pairs we have seen are usually one male and one female. In the captive setting at Berkeley, Glickman and Frank have monitored the birth process, as well as the events occurring immediately afterward, and have observed that a cub's initial, and most brutal, rank-related encounter begins shortly after birth, when it may be attacked or even killed by its littermate (see sidebar at left).

In the wild, presumably as a result of intense fighting within the natal den, rank relations between siblings have invariably been settled by the time the mother brings her cubs to the communal den. For example, Sioux, who turned out to be female, clearly dominated Cheyenne, a male, on the day they were introduced to the clan. We could tell the brother and sister apart because Cheyenne was smaller and was scarred across his back and shoulders. As Sioux settled against her mother's warm belly to nurse, Cheyenne was left to squirm his way awkwardly between Cochise's hind legs to reach her second nipple. As further evidence of her dominance, Sioux stopped her vigorous nursing after several minutes and chased her brother into the den hole, from where we could hear his high-pitched squeals.

During a cub's six- or seven-month stay at the communal den, its social world expands to include not only its group of peers but also the adult and adolescent hyenas that pay frequent visits to the den. During their first weeks there, cubs appear above ground only to nurse, but soon they begin to make tentative explorations of the new world around them. At this stage, the small, black infants are timid, tucking their tails and bobbing their heads submissively in response to virtually everything that moves, including a plant waving in the wind, a guinea fowl wandering by, or the twitching ear of a sleeping hyena. Anything unusual, even the fluttering of a small bird, sends them racing back to the security of their mother's side. Before long, however, the cubs become bolder and much more likely to chew the offending plant or chase the guinea fowl than flee from it. Every small cub also devotes considerable time to investigating the various body odors of the other hyenas it meets and presenting itself to be sniffed by them in turn.

At the communal den, cubs have little to fight over, since they nurse frequently and have access to solid food only on the rare occasions when an adult female attempts to provision her cubs. Consequently, we have few opportunities to discern rank relationships among cubs that are not siblings. Curious to know whether a hierarchy exists among cubs at the communal den, we decided to introduce an object that might elicit competition. One day we stole a Cape buffalo leg from a group of fat, sleepy lions and presented it to thirteen young hyena cubs (two to four months old) at the communal den. We chose an afternoon when no older hyenas were at the den to influence the outcome of our little experiment. Under these conditions, the cubs behaved just like adult hyenas; that is, they squabbled vigorously in their attempts to displace one another from the food. In the process, to our complete surprise, they revealed that they had in fact formed their own miniature dominance hierarchy but that this hierarchy had nothing to do with their sex, relative size, age, or their mothers' social rank. Small cubs sometimes dominated big ones, and cubs from low-ranking lineages could dominate cubs from higher-ranking fami-

R. D. Estes; Photo Researchers, Inc.



Spotted hyenas are excellent hunters, as well as accomplished scavengers and usurpers. The hyenas below may be feeding on a lion kill, since an adult giraffe generally would be too much for them to bring down. Right: an adult hyena, flanked by two eager jackals, dines on a flamingo.

Clam Haagner; Anthony Bannister Photo Library



lies. For example, Ginger, the relatively aggressive and fearless daughter of the clan's lowest-ranking female, was able to establish a position for herself at the top of the cubs' hierarchy. Our observations led us to think that, at this time of life, a cub's position may depend on its personality, particularly on the balance between fearfulness and aggressiveness.

The early dominance relationships we saw that day were not enduring, however. During the subsequent months, cubs' ranks relative to peers steadily and systematically changed. By the time the cubs reached eight months of age, the rank order among them paralleled almost perfectly that of their mothers.

How does this transformation in peer rank relations occur? Thousands of hours of watching youngsters as they grow up in our study clan have suggested various mechanisms by which cubs may "inherit" their mothers' social ranks. Cubs have many opportunities to observe high-ranking mothers harassing and attacking low-ranking mothers, for example, and might learn something about the social hierarchy by observing these interactions. Mother hyenas at the den occasionally intervene when their young cubs engage in disputes with their peers, high-ranking mothers doing so more frequently and more aggressively than low-ranking ones. For example, if the mother from the higher-ranking lineage is present when two cubs bicker over a bone or play object, she might wave her head threateningly, a gesture sufficient to discourage her cub's opponent. In addition, high-ranking mothers sometimes bring meaty bones or chunks of ungulate skin to the den for their cubs and then often intervene to make sure their youngsters maintain possession of the precious item. These provisioning events are rare but may play a key role in the reordering of cubs' relative ranks within their peer groups.

When cubs are seven to eight months old, they begin to leave the relative safety of the communal den to travel throughout the clan's twenty-five-square-mile home range. At this point many cubs begin to spend their days sleeping in bushes. Some cubs, however, go through a period in which they seek daytime shelter in one or more "transitional" dens located throughout the clan's home range. Although most are still nursing when they leave the communal den, young hyenas begin to ve
into the frenzied feeding competitio
surrounds the carcasses of freshly
ungulates. This competition, centr
hyena social biology, involves dra
displays of feeding speed and high
of aggression among clan membe
one instance, we watched a grou
twenty-two hyenas reduce the entire



of a topi (a 300-pound antelope) to a scattered bones in only thirteen min- When youngsters first encounter this enge, they are still slow and clumsy ers. They have not yet developed the mous skull bones and powerful mus- ure that enable adult hyenas to tear huge chunks of meat and crunch up s as though they were potato chips.

At these first ungulate kills, maternal intervention takes on a new importance. When cubs join the competition around a carcass, their mothers are often with them, acting on their behalf. Once, at a topi kill, we saw nine-month-old Whitey chewing on a leg joint abut 200 feet from the main carcass, where his mother, LG, was feeding with twenty-one other hyenas. Eighth Notes, an adult immigrant male, sneaked up, stole Whitey's topi leg, and ran off with it. Despite her involvement in the chaotically feeding crowd, LG noticed the theft. She burst out of the mob of blood-stained hyenas around the carcass, chased Eighth Notes 500 feet, and tackled him, forcing him to drop the topi leg. LG picked up the leg, trotted back to Whitey,



and dropped it in front of him, then returned to the fray around the carcass.

As a rule, such confrontations with adult males are unusual, for as immigrants, males generally defer to all hyenas born in the clan, even to cubs that have not yet left the communal den. Cubs' rank-related interactions with adult females are somewhat more complicated. Rank may be inherited, but older females don't simply move aside to make room for the offspring of higher-ranking females; the cubs must assert themselves. This they begin to do about the time they first feed at ungulate kills, challenging adult females much larger than themselves, as long, that is, as their opponents belong to lower-ranking matrilines. In competition over access to a wildebeest carcass, for example, an eight-month-old female named Baldy attacked OT, an adult female ranked below B mother. OT, three times larger than H tacker, initially parried Baldy's attac tried to regain access to the carcas Baldy persisted until OT backed off her tail between her legs.

Baldy defeated the older animal s handedly, but spotted hyena cubs quently join, and are joined by, othe nas in attacks against clanmates of

Joe McDonald

Juvenile spotted hyenas at play, left. While one cub (its ears forward in an aggressive, dominant position) attempts to mount a second, a third (its ears pressed back in a submissive position) playfully chews on the muzzle of the first. A four-month-old cub rubs against a sleeping adult, below, probably getting both a sense of well-being and a good dose of the clan's signature smell in the process.

David Madison; Bruce Coleman, Inc.



rnal rank. Coalitions may reinforce a
n its challenges until lower-ranking
s learn to defer to the youngster even
it acts alone.
eighteen months of age, young fe-
s have worked their way into the adult
le hierarchy, fitting in immediately
v their mothers' position and winning
heir fights against adult females of
r maternal rank. Within a matriline, rank shifts over time (younger animals outranking their older siblings), but outside the matriline, females retain their social ranks for the rest of their lives, which may be twenty years in the wild.

Young males also work their way into the adult hierarchy, but the outcome of their efforts is somewhat less certain. Often they succeed in dominating adult females from lower-ranking matrilines. Once, for example, we watched as DJ, the clan's third-ranking female, brought a zebra leg to the den for her cub, only to be intercepted by Sherlock, the six-month-old son of the second-ranking female. Sherlock grabbed one end of the zebra leg and tugged with all his might. Since DJ was almost four times his size, she easily won the tug of war. But hyenas are extraordinarily persistent, and Sherlock then went directly after DJ, assuming the full-blown attack posture, with his head up, ears forward, and tail bristled. Both animals ended up on their hind legs, with DJ parrying defensively against Sherlock's attack. Eventually she backed away, and Sherlock made off with the zebra leg.

Many other times, however, these young males must accept a position in the hierarchy lower than their mother's rank would suggest. By eighteen months of age, for instance, they win only about half of their fights with adult females from lower-ranking matrilines. The status young males attain during this period remains unchanged as long as they remain in their natal clans. But eventually, the males go off on their own, and the minute the young male hyena leaves his natal clan, his social status plummets.

Young males dispersing to the home range of a new and unfamiliar clan revert to a cublike pattern, attempting to appease everything that moves. Neighboring clans are often hostile toward one another, and because outsiders are not always welcome, the young male must somehow break through this barrier. During an encounter with an adult male in unfamiliar territory, the new immigrant slinks toward the other male and crouches before him with his head twisted and lowered, his ears plastered back against his head, and his lips curled in a submissive grin more exaggerated than any we have seen in any other context. Usually he is simply ignored by the animal he is trying to appease, but sometimes he is chased all the

Jeremy Woodh

Spotted hyenas inhabit many different habitats of sub-Saharan Africa, including Botswana's Okavango Swamp, below. Right: Wherever they are, hyenas greet fellow clanmates by sniffing each other's genitals, a "handshake" that may last several minutes.

Frans Lanting; Minden Pictures



way back to the edge of the new clan's territory. Often the young male will return again and again, until his presence in the new clan is accepted. Sometimes, however, males give up and move on, exploring several clans over a period of several months before finding one to join.

A young male in a new clan will be subordinate to all the adult females he encounters, as well as to all immigrant males that joined before he did and to all the youngsters—male and female—born in the clan. In sum, when a male leaves his natal group, he gives up all of the power and privileges associated with his birthright. Over time, as he becomes one of the senior immigrants, he will be able to dominate more recent immigrant males, but he will remain a second-class citizen indefinitely, subordinate to members of the natal clan.

Why then do males leave home? Although we don't yet know the answer with absolute certainty, much of our current fieldwork is devoted to addressing this and other questions of dispersal. We do know that males leave their natal clans voluntarily, without any aggressive prompting from other clan members. We believe that their departure must have to do with their search for females that will accept them as suitors. After reaching reproductive maturity (at about twenty-four months of age) but before they emigrate, males born in our clan often attempt to court female clanmates. During this courtship, natal males may threaten and chase away a immigrant males that also attempt to co sexually attractive females, but the males don't appear to take the courts gestures of natal males seriously. We s pect that females prefer to mate with i migrant males—a pattern of female cho that could have evolved to minimize deleterious effects of inbreeding.

Our hope is that as we track more a more of "our boys" in their journeys aw from home, we will gradually come to derstand better the reasons for their mo ments. One day, we hope to be able to port that, like their sisters at home, th too are fully accepted, reproductively s cessful members of hyena clans of Masai Mara.







Landing near its nest on Enderby Island, a brown skua greets its mate by raising its wings.

Low, Lean Killing Machine

When a bulky skua hunts rabbits, the bird undergoes a startling transformation

Text and photographs by Fred Bruemmer

Skuas are easy to hate. Large, gull-like predators, they kill fellow seagoing birds such as prions and petrels, rob penguin nests and gulp down fluffy chicks, bully gannets and terns into disgorging hard-won food, and divebomb humans with precision, showering them with excrement and sometimes knocking them down. Botanist Mary Gillham, who visited sub-antarctic Macquarie Island in 1960, wrote lovingly about its penguins, then turned a hostile gaze upon the skuas: "The foulest of plunderers," she called them, "the rudest of the rude."

The skua is bipolar; it is the only bird that breeds both in the Arctic and Antarctic. Until the 1900s, the northern or great skua (which the Scots call a bonxie, a name related to the Old Norse word for an untidy, dumpy woman) nested only on southern Iceland and on the Faroe and Shetland islands, and even there it was rare. Hard-up crofters raided skua nests, taking eggs early in the season and fat chicks just before they fledged. British naturalist Thomas Pennant reported that if a parent skua divebombed, the nest robbers "hold a knife erect over their heads, on which the Skua will transfix itself." At

Descendants of animals brought to the island to provision ships, feral rabbits, below, feed on Enderby at dusk. A bird adopts the stalking posture peculiar to skuas hunting young rabbits on foot, top right. After a successful hunt, a skua pair tears off small bits of prey, middle, which their chick takes from the parent's beak, bottom.



the end of the 1800s, only a few hundred great skuas survived.

Since then, when preservation measures were sporadically initiated, the skuas not only have increased but also spread: to the Orkneys in 1914, to the Scottish mainland in 1950, to Spitsbergen in 1970, and to the arctic island of Jan Mayen in 1984. Robert W. Furness, author of *The Skuas,* estimates their present numbers at about 12,500 pairs.

Southern clan members are the Chilean skua, which breeds along the coasts of Chile and Argentina; the Falkland skua, smallest of the skua races; the subantarctic brown skua; and the south polar skua, which breeds on the fringes of Antarctica and on nearby islands.

Whether north or south, skuas are notoriously belligerent, "the fiercest of seabirds in defending their young," wrote Canadian biologist William J. Maher. The exception is the brown skua on Enderby, one of the Auckland Islands between New Zealand and Antarctica, which I visited for three months in the 1980s. Like other skuas, brown skuas are expert pirates, but toward humans, they are quite pleasant and mild mannered. They tolerated me on their territories with little complaint and were not upset when I came close to their nests and, later, to their chicks. Some of the Enderby Island skuas also have a peculiar specialty: they hunt young feral rabbits, on foot in the forest.

About one hundred pairs of brown skuas nest in the Auckland Islands, about forty of them on food-rich Enderby, the northernmost island of the group, 300 miles south of New Zealand. Six miles long and three miles wide, Enderby is lush and verdant. A dense forest of gnarled rata trees, a species of New Zealand hardwood, covers about half the island, hemmed by thickets of storm-sculptured myrsine and cassinia bushes. Rimming the island are deep green meadows. These areas were once covered with hummocks and tussock grasses, which were cut down and converted into lawn-smooth sward by Enderby's large population of rabbits.

The Auckland Islands were discovered in 1806 by Abraham Bristow, a British whaler bound for London from Australia. Soon, sealing gangs from several nations came to the islands to kill the numerous and valuable fur seals and the less numerous and less valuable sea lions. (The sealers were a rough lot. Lord George Campbell of Britain's *Challenger* expedition met a shipful of them in 1874 and remarked dryly: "Most of the crew look as if they had left their country for their country's good.")

The sealers, and later, explorers and New Zealand government ships, brought rabbits, goats, pigs, and cattle to the Aucklands to provision future trips and feed castaways. Rabbits were introduced to Enderby Island in the 1840s; those on the island now are of a French breed known as Argenté de Champagne. In 1874, the New Zealand ship HMS *Blanche* visited Enderby and found it overrun with rabbits. During World War II, the hunted German raider *Erlangen* refueled with rata wood in the Aucklands and then escaped to Chile. For some time after that, New Zealand coast watchers were stationed on the then uninhabited islands. They shot at least a thousand rabbits a year on Enderby, but the prolific animals remained abundant; some 4,000 adult rabbits now inhabit island. Skuas are their only enemy.

The New Zealand falcon, the Au lands' sole raptor, is rarely seen on derby and does not kill rabbits. No ma malian carnivores live on the islands. skuas are Enderby's main predator also the main scavenger (with red-bi gulls and southern black-backed gulls minor competitors). Skuas patrol the land's beaches and pick up anything ible. They stand attentively near the land's large Hooker's sea lion rook where they eat placentas and feces. W sea lion pups suckle, skuas often st nearby to peck up drops of spilled m They clean up around the living and t consume the dead. The skua's scien name, *Catharacta,* means "purifier" "cleanser."

Many other island birds fear skuas, v good reason. The females, larger heavier than the males, are big, powe birds with a nearly five-foot wingspr and black, hooked bills. In New Zeal the red-billed gulls breed in open colon but in Enderby, they hide their nests un boulders and in caves to protect them fr skuas. The flightless Auckland Island t a small duck, raises its young deep in







dark rata forest and usually leads them to sea at night. The dainty Auckland Island shag, a kind of cormorant, nests on extremely narrow ledges where skuas have trouble landing. Yet even there, shags are not safe, for skuas are shrewd and determined. A skua will fly to the ledge, lock bills with a frantically jabbing shag, yank the bird off its nest and drop it, then rush in to grab an egg or chick.

Skuas are opportunistic; they often appear somnolent and lazy but are actually observant and astute. One day I washed my hair, and with my eyes full of suds and smarting, I groped for the soap, but it was gone. A skua had quietly walked up and filched it. Skuas also appraise sea lion behavior. Greedy pups often drink far too much milk and later vomit. Skuas know the telltale signs of a pup in distress; they await the event and eat the upchucked curdled milk. Sea lions regularly ingest stones on the sea bottom near shore, swallowing anything from pea-sized pebbles to rocks the size of golf balls. Back on shore, amid much heaving and retching, they occasionally spew out these gastroliths together with remnants of recent meals, welcome food for eager skuas.

Between thirty and fifty skuas, nonbreeders and off-duty nesters, are usually in attendance at the Enderby sea lion rookery. I once watched sea mammal expert Martin Cawthorn cut up a sea lion carcass to collect tissue samples and to determine, if possible, the cause of death. A horde of skuas clamored around him. One skua (weighing less than four pounds) bolted down a one-pound chunk of liver, then sneaked in for another helping. When Cawthorn left, the skuas rushed to the carcass. A brownish, vulturine mob, they tugged, ripped, and gorged. Such a carcass, providing at least two hundred pounds of fat and meat, was certainly big enough for the whole group, yet the skuas spent more time fighting than feeding. They raised their wings in threat display, arched their necks, lowered their heads, and screamed. They fluttered up and hacked at newcomers. Two skuas faced each other, puffed out their chests like



pouter pigeons, and bumped each other, then rushed back to the feast. Finally sated, they flew to a nearby brook, splashed, and washed, for they are very cleanly, then settled on the sward to doze and digest.

As competitive as skuas are, even they, at times, must cooperate in order to eat. When skuas attack a heavy, immobile sea lion carcass, they brawl nearly constantly and chase and intimidate rivals. But faced with a smaller morsel that yields when pulled, yet is too big to be swallowed whole—a stretch of sea lion gut, for example—skuas are in a quandary. Alone, they cannot manipulate such a meal; unlike the talons of a raptor, which hold the food while the bird tears off bite-sized bits, the skua's flat, webbed feet are unsuited for pinning down and holding prey. In such a situation, an Enderby skua might drag a ten-foot piece of gut across the sand, then sit with its trophy and wait. If another skua approaches, the owner of the gut does not protest. Each bird grabs an end of the gut and pulls, tug-of-war fashion. Whichever bird tears off a piece small enough to be swallowed gulps it down while its partner waits. Slowly, the two skuas share the length of gut, their normal, agonistic behavior held in abeyance, since only cooperation makes the meal possible.

Near its nest, the skua is fearless, "one of the boldest and most ferocious defenders of home and family in the avian world," according to American biologist Carl R. Eklund, who studied skuas for many years. On Gough Island in the South Atlantic, Robert Furness found that in October skuas with newly laid eggs were relaxed and unruffled when he came close, but one month later, when the eggs were hatching, the skuas were, as elsewhere, aggressive: "traveling at upwards of 10 metres [33 feet] per second," he wrote, "[they] hit hard and if that failed to drive me away...they would land on my head and start pecking vigorously if I failed to fend them off." The Enderby skuas, however, tolerate humans on their territories at all times. At first they were mildly annoyed, then casually indifferent. None of the twenty pairs I visited ever attacked in earnest with the knockdown blows skuas use elsewhere.

Most skuas nest toward the forest edge, often in the lee of small myrsine bushes. I frequently visited one pair that nested near our camp. When I was some twenty yards away, the female on the nest would begin to cry, a harsh rasping call that escalated into strident yells as I came closer. The male, which stood guard nearby, would fly up, hover above me, then settle softly on my head and pluck tentatively at my woolen cap. If I sat down beside the female and talked to her, she soon ceased her angry keening.

At times I would stretch out my hand and stroke the brooding bird. She would look at me with interest, but no fear, and nibble at my sleeve. If I slid my hand beneath her and pushed her gently off nest, she protested with a couple of c but did not otherwise resist. The nest an untidy collection of grasses, liche mosses, and twigs. In a shallow depress in the vegetation lay two faintly brown eggs blotched in tan and sienna. After inspection, the female cooed, stood c the nest, fluffed her feathers, turned arranged the eggs to her liking, and set upon them with a shuffling motion.

Meanwhile, the male would have turned to his guard post on a little kn From time to time, as if aware that he remiss in his duties, he flew up, circl approached from behind, and grabbed anorak hood. Once, flapping his gr wings with all his might, in his best *Ea and Ganymede* imitation, he tried to ca me up and away.



Skuas frequent the large Hooker's sea lion rookery on Enderby Island. Even in the midst of a windfall such as a sea lion carcass, the belligerent birds spend more time fighting over food than feeding, left. Opportunities for snacking abound at the rookery. A skua attends a sea lion mother and newborn pup, below, hoping to devour the afterbirth.



ter a while, both birds ignored me. hey will not tolerate another of their Skuas mate for life. The nest area is ocal point of their existence, where and female meet again and mate after ering separately during the southern r. A patch of ground about a hundred cross, and a much larger aerial space e it, is their exclusive realm, which defend against all other skuas. A spe- oud, wild yodel means "strange skua e vicinity," and the off-duty bird rises ntly to chase the intruder away from erritory. One reason for this intense gonism, said Eklund, is because the a is its own [and Enderby's only] ator." They are not at all averse to eat- neighbor's eggs or chicks.

n Enderby, the female skua does most e incubating, about three times as much as does her mate, whose main duty is guarding their domain. If the female overstays her time on the nest, the male becomes broody and impatient. He walks to the female and "talks" to her in wheezy, urgent chirps. She usually ignores him, and he becomes even more insistent by nibbling her neck and, if even this elicits no response, tugging at her tail. Reluctantly, the female yields. The male immediately and eagerly settles on the eggs. She stands near him for a few minutes, then flies off to eat and bathe.

I found twenty skua nests on Enderby and each held two eggs, yet later, all the skua pairs but one raised only a single chick. The female lays two eggs over a two- to three-day interval, but she begins to incubate after the first egg has been laid. As a result, the chicks usually hatch one or two days apart. The older chick, first to be fed and quick to grow, tyrannizes its sibling. The first chick is louder, quicker, stronger, and gets most of the food brought by the parents. It hacks and pecks the younger chick until the victim leaves the nest and wanders off. Unable to fend for itself, this chick may die of hunger and exposure or be eaten by neighbors or even a parent, a practice called cronism after the mythical Cronus, the Titan, who ate all but one of his children.

Having rid itself of its rival, the remaining chick receives the parents' undivided attention and all the food they can supply. While one parent forages, the other guards the chick. At this time, skuas elsewhere are at their most aggressive, as battered chick-banding scientists have reported with some asperity. But the Enderby skuas remain complacent. I could approach and even hold their chicks; they sometimes yelled but never attacked.

The skuas bring their chicks a wide range of foods, but the island specialty is rabbit. The adult rabbits are a smoky bluish gray in winter, reddish brown in summer. Skuas rarely bother the adults, and if they do, it is only from sheer devilry. A skua skims across the sward, zeroes in on a peacefully nibbling rabbit, swoops down, and knocks it spinning. Despite such abuse, with no true enemies on the island, adult rabbits are quite unconcerned and come out at dusk or even in daytime to feed. But skuas do prey on the jet-black baby rabbits. The young are wary and skittish and spend nearly all their time in the forest, where the skuas go on foot to hunt them. Stalking behavior appears to be in-

Its wings raised in a threat display, a skua that was too slow in gobbling up a rabbit defends its catch against rivals.



nate in skuas, but on Enderby the victim and venue are unusual. Scientists with powerful flashlights have seen skuas stalk prions and petrels at night. Young birds do not watch the adults hunt, so presumably each bird acquires the technique by trial.

The Enderby skuas normally are bulky in shape and shrill in tone. A skua on a rabbit hunt is transformed. Its feathers sleeked, a new, low and lean skua skulks through the forest. The moment it spots a baby rabbit, it freezes, presses itself to the ground, and studies its intended victim for several minutes. Then, using every bush, every unevenness of ground, the skua stalks the rabbit with finesse. If the rabbit eats, the skua rushes forward with quick, short steps. The instant the rabbit is alert, the skua stops. From about five feet away, the skua pounces, grabs the rabbit with its hooked bill, carries it from the forest onto the open sward where it cannot escape, and kills it with repeated blows. The bird then rips the rabbit open, eats the viscera, and grasping the carcass by the head, swallows it with a few convulsive gulps. When the skua returns to its territory, it disgorges the entire, limp carcass for its chick.

The parents greet each other with raised wings and loud calls. The downy chick cheeps, jumps up and down, flaps its tiny wings, and pecks the chest and neck of both parents. In response, the parents grab the rabbit carcass and pull. Whichever parent tears off a piece small enough to suit the chick feeds it to the begging youngster.

Amply fed, the skua chicks grow rapidly. On Enderby, most chicks hatch in December. By February, they have molted into black-brown plumage and are nearly as big as their parents. In another month they will fledge and be on their own. Immature skuas roam far, but when they are about five years old, most of them will come back to the island of their birth to select a territory, to find a mate, and to raise the next generation. They will also carry on the peculiar island tradition, honing their rabbit-stalking skills in the rata forests of Enderby Island. □



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Have Camera Will Tra

by Richard M. Ketchum

In a day when superb wildlife films are a regular occurrence on television, and the technological marvels of nature photography are scarcely noticed, Americans forget the vicarious thrills they experienced in the twenties and thirties through the pioneering motion pictures of Martin and Osa Johnson.

The husband and wife who were such preeminent figures in this field only a half century ago are all but forgotten today, and the films on which their reputations were built survive largely in the vaults of museums and libraries or in the dimming memories of old-time moviegoers. So their story, told by Pascal and Eleanor Imperato, is as fresh as it is welcome.

Pascal Imperato discovered the Johnsons when, as a teen-ager, he stumbled onto one of Osa's books in the travel section of his local library. Throughout high school, college, and medical school, his interest in the couple and in Africa grew, and a fellowship afforded an opportunity to visit East Africa during its colonial twilight. Later, he and his wife, Eleanor, spent a great deal of time there, getting to k many of the places and people assoc with the Johnsons.

Motion pictures have the special qu of transporting the viewer into an world, and in the case of the Johns films, that world was equal parts mys and terrifying reality. People who n never travel more than fifty miles their hometown could sit in a shad theater—onlookers, enthralled by sc from "darkest Africa" or "wildest neo," as the billboards called them— even as their pulse rates climbed high tune with the action, they could take fort in the knowledge that it was Osa J son—not them—being charged by the noceros.

This American couple discovered secret of simultaneously entertaining enlightening audiences by leading t through untracked jungles and up the ering crests of mountains; revealing customs of primitive tribes; and intro ing them to exotic birds, animals, and tiles that were already beginning to va



Martin Johnson is seated on the floor between Jack and Charmian London at a masquerade party, Solomon Islands, 1908.
Jack London Collection, California Department of Parks and Recreation

e the onslaught of white hunters,
ers, and Western civilization. The
rops against which the action took
were some of the most remote lands
th, and for a majority of Americans,
e opportunities for foreign travel
almost nil, the lure of those faraway
was just about irresistible.
e rising popularity of the attractive
Kansas couple paralleled the story
tertainment in twentieth-century
ica, for they made skillful use of the
nedia technology developed in their
ne. They began their career with il-
ed lectures on the vaudeville stage,
progressed to silent films, radio, and

MARRIED ADVENTURE: THE WAN-
G LIVES OF MARTIN AND OSA JOHN-
by Pascal James Imperato and
or M. Imperato. *Rutgers University*
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g pictures. In addition, they pub-
l numerous magazine articles and
. While satisfying their own craving
venture, they brought the fascinating
ittle-known world of wild animals
primitive peoples to Americans,
e own frontier had been tamed not so
years earlier.
nen Martin Johnson was born in
the Indians and great herds of bison
but recently gone from the Kansas
es, replaced by the plow, the railroad,
lusters of settlements. Whatever in-
he might have had in formal educa-
vas stifled in a one-room schoolhouse
d with ninety pupils. A strict teacher
n exacting father drove him to run
from home regularly—a habit that
t be said to have persisted for the rest
life.
artin's first taste of adventure came
he persuaded the famous novelist
outdoorsman Jack London and his
Charmian, to take him as a crew

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PHOTO: NAPOLEON CHAGNON

YANOMAMÖ

THE LAST DAYS OF EDEN

THE CELEBRATED ANTHROPOLOGIST'S PIONEER WORK AMONG A NOW-IMPERILED AMAZON TRIBE

NAPOLEON A. CHAGNON

Foreword by Edward O. Wilson

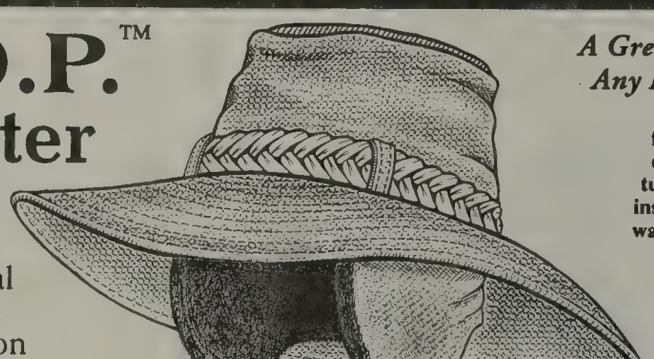
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member on what was planned as a se year voyage around the world aboard *Snark*, a fifty-seven-foot ketch desig by London.

Setting sail from San Francisco in 1 aboard the leaky, poorly built craft wi shifting crew that included drunks, rasc and a murderer, the Londons and yo Johnson called at Hawaii, the Marque Tahiti, Samoa, the New Hebrides, and Solomons before serious health probl forced London to sell the *Snark* and ab don his ambitious plans. During their years at sea, they had been exposed to quent danger from native peoples and most constant risk of shipwreck beca of a cranky vessel and an inept crew. the experience determined forever the rection of Martin Johnson's life.

Toward the end of the *Snark*'s voya Martin, already an accomplished still p tographer, worked with a French film c producing motion pictures, which quickly recognized as the ideal med for exotic scenes of faraway lands. Equ influential was his admiration for the L dons. Martin perceived them as the mo couple—Jack brave, determined, fore seeking risk and excitement; Charmia skilled shot, as courageous as she sweet and feminine, the ideal partner traveling to wild areas.

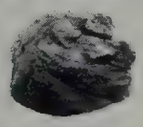
Returning to the United States in 19 Martin became a travelogue lecturer us his photographs of the *Snark*'s voyag the first of many instances in which capitalized shamelessly on the Londo name and reputation. The following y back in Kansas, he met the sixteen-y old Osa Leighty and, after a br courtship, eloped with her. Martin m have seemed the ideal man to the sta struck girl: he was tall, handsome, and acclaimed world traveler who exuded pealing country boy manners." And s clearly, was what Martin wanted i wife—beautiful, charming, and willing assume a role (although not an equal o as the Imperatos frequently point out her husband's life and career.

Until 1917 they traveled the vaudev circuit, with Osa singing Hawaiian so while Martin provided the commentary his films. Then a group of Boston vestors put up $7,000 to send them to Solomon Islands and the New Hebrides make a motion picture.

When they sailed from San Francisco was the first of many occasions on wh Osa would leave home reluctantly, only refuse to be left out of the action wh they arrived at their destination. Reject

's pleas that she stay with mission-
she insisted on going along and was
laying the lead in his film—a pretty,
-haired white woman, posing and
niming with fierce-looking natives.
ormula would eventually lure thou-
of fans to the box office.
lic taste has not changed noticeably
then. Although the Johnsons' films
exceptionally valuable as documen-
what moviegoers wanted was sen-
alism, and Martin was continually
lookout for sure-fire box office ap-
-cannibals, headhunters, the "miss-
k," and above all, action.
921 he had the good fortune to meet
Akeley of the American Museum of
al History. Akeley, a leading author-
African wildlife,was deeply con-
d that the great animal herds were
ed to extinction. He sent the John-
on an expedition to Kenya to docu-
vanishing species. Martin's film, in
helped him raise funds for a new
an Hall at the Museum.
the time, almost all the photographs
ldlife in East Africa had been taken
ofessional hunters and sportsmen on
, and the results were mostly ama-
h and uneven. Thanks to Akeley,
wanted him to use his skills in the in-
of science instead of the entertain-
industry, Martin met the noted natu-
Arthur Blayney Percival, who
ed him on the many details of safari
wildlife habits, the best methods of
ning photographs, and, not least, how
lect a headman, reliable servants,
earers, porters, and an excellent
sman to cover them with a rifle when
got too close to dangerous game.
hile shooting scientifically valid films
ldlife in their natural state, as Akeley
ed, Martin never lost sight of the pub-
appetite. "It was all well and good to
hino browsing and trotting across the
s," the Imperatos write, "but such
es were no substitute for a rhino
ging the cameraman." Or Osa—who
egularly sent out with rifle in hand to
oke an elephant or lion while Martin
ked the camera. Although she had be-
e a crack shot and was covered by an-
, this was still highly risky business,
t became a hallmark of the couple's
an films and contributed largely to
success.
nd success it was, as expedition fol-
d expedition until Martin's untimely
n in a plane crash in 1937. By then the
sons were celebrities. They had trav-
countless miles (never to South

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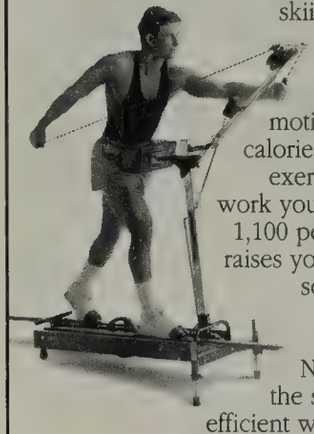
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Nairobi, 1926: Martin and Osa Johnson, left, with Kodak inventor George Eastman, center, who invested in the Johnsons' expeditions.
Photographs courtesy of the International Museum of Photography at George Eastman House

America, however) and left a prodigious photographic legacy. Their African movies—among them, *Trailing African Wild Animals, Simba*, and *Baboona*—received rave reviews from critics and public alike. In addition to magazine articles, they published a number of books on their adventures, including *Camera Trails in Africa, Safari, I Married Adventure,* and *Four Years in Paradise*.

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Richard M. Ketchum is the founding tor of Blair & Ketchum's Country Jou *His most recent book is* The Borr Years, 1938–1941: America on the W War *(Random House, 1989).*



Osa Johnson with Mbuti Pygmies at Bwana Sura in the eastern Congo, 1930.

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A Two-Faced Grain

Because of its chemical structure, rice may be cooked simply or exotically

by Raymond Sokolov

So there we were once again in the sheltered precincts of Saint Antony's College attending the annual Oxford Food Symposium. The topic for 1992 was "flavourings," and this was interpreted by the nearly 200 participants with the usual mixture of scholarship, wit, and eccentricity, which always makes the symposium unique among learned meetings. One might even say that this year the symposium had more than its usual flavorsome mix of rigor, vigor, and flair.

As always there were the founding fathers, the ichthyopolymath Alan Davidson and the *genius loci,* Saint Antony's own social historian of France, Theodore Zeldin, presiding with deceptive detachment over the controlled chaos of the mid-September weekend. Typically, there was no attempt to straitjacket the proceedings with a theory or a definition of the topic, even though the notion of flavor (and its media) is complex and elusive. Had we been gathered in Paris, the entire event would no doubt have been given over to fractious discussions of basic terms (*Qu'est-ce que c'est que la saveur?*).

They order things differently in England, and the result was a hundred blooming flavors wafting about, intellectually as well as physically, at an exhibition, a tasting (chocolate), and meals (the usual multiculinary potluck lunch, a remarkable Persian dinner, and a table of English cheeses).

The intellectual smorgasbord of sessions, small and plenary, offered an alimentary range of globe-girdling diversity. Magomedkhan Magomedkhanov reported on some mountain dishes of his native Dagestan, an autonomous Caucasian republic still nominally loyal to Moscow. Doreen G. Fernandez, although absent herself, contributed the text of a rich discussion of the idiosyncratic flavor principles of her native Philippines.

There were presentations on maple syrup and on salted food in Danish history, on the spice trade and on home-grown flavorings such as mint. I could go on and list the subjects of all the papers, but even that would not convey the event in its entirety, especially since many sessions occurred simultaneously, and the discussions are the heart of the symposium. Following a certain path through the scheduled events, one might have concluded that this was an uncharacteristically flamboyant symposium with hashish, hedonism, and hot food at its center.

Now that I have had the time to recollect things in tranquillity, however, and to read through all the papers, I believe I have detected three improbable trends with no discernible common bond between them.

First, and most surprising, was the sheer number of papers dealing with the world of Greek and Roman antiquity. Indeed, there were no fewer than three papers on the subject of silphium alone. What was silphium? I can recall wondering exactly that as a student of the classics. This prized substance seemed to have a slightly suspicious character, naughty *and* nice. My professors shed no light on the matter and I took to translating it as silphium.

Symposiasts ransacked the ancient evidence, historical, epigraphic, and numismatic. The consensus was that silphium was a highly prized resinous derivative of the root of a giant, fennellike umbellifer. There was a brisk trade in it centered in what is now Libya. The plant mysteriously disappeared, but we can get a good idea of what it tasted like from the spice called asafetida. Most widely used in India (where it is best known by its Hindi name, *hing*), asafetida has a musty odor that reminds people, variously, of excrement, sweat, and the smell of sexual arousal.

There were also more mundane investigations of classical cookery, including surveys of flavorings in Roman Britain and the flavors of ancient Greece. S the main source for ancient gastrono Athenaeus' *Deipnosophistae,* or Philosophers at Table," itself a ki pseudosymposium, one could see th tification for discussing this often te and untrustworthy anthology of gou musings. John Wilkins and Shaun maintained that much of the materi Athenaeus really is a good guide to c cal dining, and their paper attempted tract fact from epicurean fantasy. fallen-away classicist, the most impre of these antiquarian papers was a reading of the pseudo-Virgilian p "Moretum," which Margaret Visser lyzed as a mock epic recipe for p pesto as prepared by a poor working

The second trend, really a trend was probably nothing more than a co dence. Three symposiasts wrote pape mastic, the Old World's original che gum and still a flavoring in many tional dishes of the Levant.

The third and least probable trend the concentration of interest in choc Here was Sophie Coe bringing forwar evidence for the flavoring of chocola its ancestral ground in ancient Me And there was Alice Wooledge Salmo lating her experiences in the upper d of the professional world of fine choc manufacture, wholesale division. Salmon evidently spent much time an fort penetrating the inner circles o "bean men" who buy *Theobroma cac* raw nibs from Venezuela to the I Coast and convert it to elite form chocolate. Next came a confusing smug presentation of subtly flav chocolates from a French chocolatier.

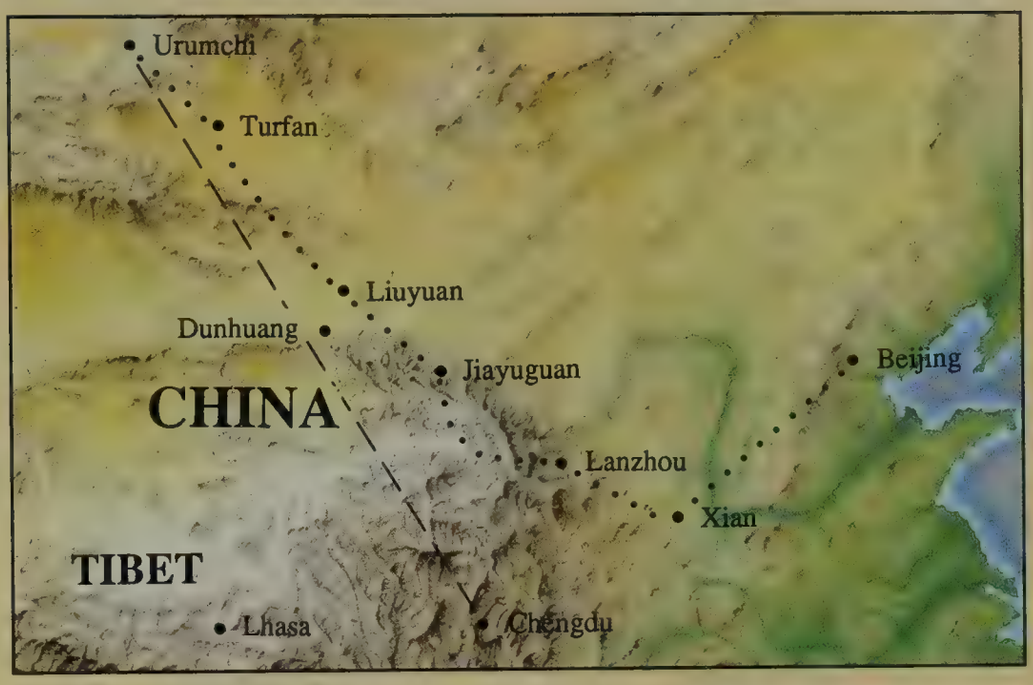
How entirely pleasant and enlighte then, to sit down with Sri Owen's wardly modest paper "Flavours for F and discover in it a quietly encyclop discussion of rice cookery, its history sociology, and the dynamic possibi

ideas open up for cooks in the poly-
world of the modern kitchen.
en, a Sumatran long resident in Eng-
nd a figure in British gastronomic
egins with Cartesian clarity:

f the attractions of rice, for the cook as
s the eater, is that it absorbs flavour
ut losing shape or texture. A grain of
and polished rice consists almost en-
of starch granules separated by walls
lulose. As the water in the saucepan
aches boiling point, the rice grains
nize—that is, the cellulose walls rup-
nd water, or another cooking medium,
in. The rice will absorb any flavour
he medium can transport into the
of the grains. Yet the grains stay
and separate.
ere are thus two basic ways of cooking
with flavouring, and without. I think it
adly true to say that people in coun-
vhere rice has for long been the major
and the staple food always cook their
lain, at least until eating habits have
deeply influenced from outside their
rs. They may eat highly-flavoured
with their rice, but the rice itself is
d or steamed and comes to table
—that, after all, is the whole point of
ning the rice to begin with. Where the
tself is coloured and flavoured, we ex-
to find that the cooking method and
e originated in areas where rice is a
dary crop, or has been quite recently
duced.

aving stated this universal principle,
n looks for exceptions and finds one
at home in Southeast Asia, where
s often cooked in coconut milk or col-
yellow with turmeric. Such dishes are
lly exceptions to the general rice-
e rule and are meant for special occa-
or for feting guests.
s Owen explains, most flavored rice
es—such as risotto and paella, both
d in stock—arose in food cultures
e other grains were cultivated first
rice introduced later.
Owen's view, the rice bringers were
lly armies on the move. She can't doc-

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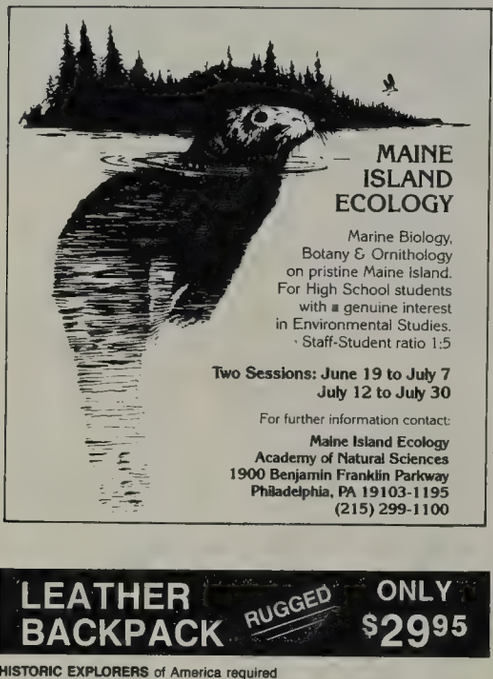
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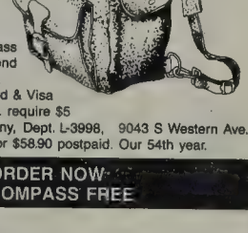
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ument this, of course, and says s there is little doubt that rice was im to the Mediterranean from Asia as p the Islamic migration.

The most historically complicate of rice cooked in flavored media is in India. Now-traditional rice dish lafs and *biryanis*, are all produc steaming rice with other flavorful in ents in tightly sealed vessels. This m is known as *dum* cookery.

If Owen's theory is correct, this category of flavored rice dishes ou be anomalous in the heart of rice's continent. Indeed, pilafs and *biryan* part of a historical subcategory of cuisine, the food of the Moguls, inv from the Islamic west. So *dum* steam an import, brought in by soldiers Persian heritage.

Owen's overall theory about fla rice applies to the present (and to t ture) as well as to the past. She pr that as cosmopolitan forces mak

Sri Owen's Nasi Ulam

Owen writes: "This is a so Malaysian version of what the I adapted from India and called ked Instead of butter, we use thick co milk, boiled (with spices) until the becomes oil, and the rice turns from the green and fragrant herbs been heated with. I first ate Nasi in a Nonya restaurant in Petaling just outside Kuala Lumpur. Nonya is a mingling of traditional Mala cuisine with Chinese, and is said to originated in sixteenth-century lacca, where Chinese immigrants ried local people. The ladies wer litely addressed as *Nyonya* or *N* which means something like 'Ma They must have been good cooks this particular restaurant does memory credit. My only criticism Nasi Ulam was that the chef had b bit too generous with the herbs, so could hardly taste the rice. In my sion I have included a list of herb you can use, but I would recom that you select just four or whichever are most easily availabl result will be better than if you t stuff them all in."

About 2 pounds plain cooke rice, left to cool to room temperature
1 pound cold smoked mackere haddock [finnan haddie], *the skin and bones removed and the flesh finely flaked*
4 tablespoons freshly grated c conut, toasted (optional)

smaller, even entrenched rice-con-
g regions will increasingly regard
only one of many possible basic in-
nts. The implication is that flavored
ill become more common in tradi-
rice cultures and that the future will
nt cooks with novel aesthetic deci-
"Will these ingredients make sense
er?" Owen seems buoyed by the
ossibilities but determined to remind
ne importance and usefulness of tra-
She points out that a great many of
ew" East–West dishes on glamorous
around the world are not new. For
le, she says that almost all recipes
e with herbs are similar to "a fine old
esian/Malaysian dish, Nasi Ulam."
ony is that this "old" dish is the re-
a hybrid cuisine invented by Chi-
mmigrants in Malay centers.

*ond Sokolov is a writer whose spe-
terests are the history and prepara-
f food.*

cup very thick coconut milk
teaspoon cayenne pepper
shallots, thinly sliced
teaspoon finely chopped ginger
teaspoon salt
About 1 tablespoon each of 4 or 5 herbs from the following list:
Turmeric leaves
Basil
Mint
Watercress
Kaffir lime leaves
Lemon grass (use only the soft leaves)
Scallions
Wild ginger flowers
Green chilies, seeds removed

e added just before serving:

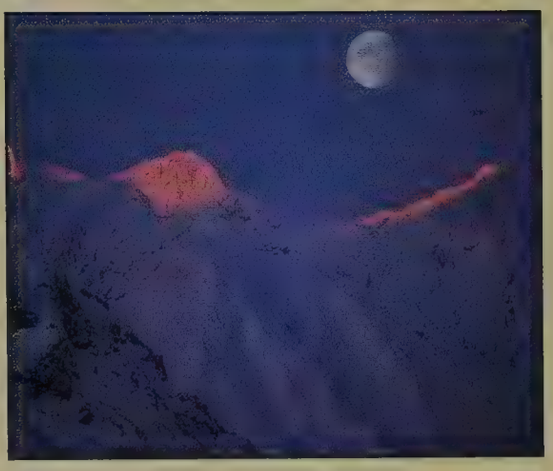
Juice of 1 lime
Salt to taste

Put the cold rice in a large bowl and mix in the flaked fish and toasted coconut (if used).
Put the coconut milk into a wok or arge shallow saucepan, with the cayenne, shallots, ginger, and salt. Bring this to a boil and let it bubble for 8 to 10 minutes, until it becomes oily. Stir, lower the heat, and stir in the rice mixture. Toss and stir this for 3 minutes, until the rice is hot. Add the sliced and chopped herbs and continue stirring for 1 minute more. Add lime juice and more salt if needed. Serve hot or warm.

Yield: 6 servings

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In conjunction with the quincentennial celebration of Columbus's voyage, the Education Department will offer free programs that examine Asian cultur after Western contact. Performances the Kaufmann Theater will inclu Philippine music and dance with stor telling by the Karadya'an Ensemb three plays by the Pan Asian Reperto Theatre, Japanese court dances by the Ha Kyu group, and a lecture about f teenth-century China by historia Jonathan Spence. Other events tal place throughout January, on Saturda and Sundays between 1:00 and 4:00 P. in the Leonhardt People Center. For complete schedule of events, call (21 769-5315.



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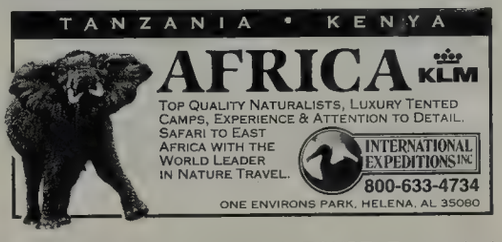
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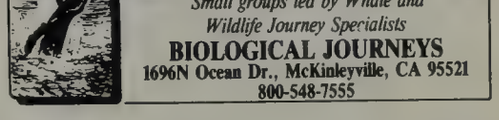
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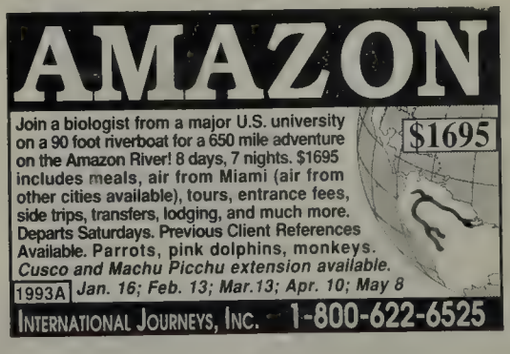
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High above a rookery in Venice, Florida, two great egrets settle a dispute. The birds' sharp bills might appear to be lethal weapons, especially when thrust at the opponent's neck, but contestants are rarely injured by the aerial jousting. This squabble began on the ground when one bird ventured too close to the other's nest. The birds then launched themselves into the air, and a stiff breeze helped hold them aloft for a brief time while they lunged at each other.

In February, during the height of mating season, such disputes often erupt in the small rookery, where space is limited and male egrets must vie for a patch on which to build their nests. Even more frequent, however, are confrontations between male and female. (Because both sexes display the same breeding plumage—bright, lime green feathers around the eyes and long, wispy aigrettes below their tails—distinguishing between the two is extremely difficult.) After claiming a nesting site, a male egret waits for courting females to come to him. Those he deems unsuitable he drives away. Launching himself at an approaching female, he will often engage her in a short aerial battle. He may reject more than half a dozen females before selecting a mate.

The two then settle down to nest building, but the peace does not last; when the female departs for several days of foraging before laying her eggs, the male resumes the courting ritual. He does not choose another mate, however, unless his first one fails to return—what one ornithologist has called "divorce insurance." —*R. A.*

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AUTHORS

"Current knowledge of mantis natural history is very meager," states **David Yager** (page 28). To remedy that situation, he raises and studies praying mantises in his laboratory at the University of Maryland, where he is an assistant professor of psychology. Yager (right) first became interested in the auditory capabilities of mantises—and was part of a team that discovered the elusive mantis ear—while he was a doctoral student at Cornell University. There he met another doctoral student in the section of neurobiology and behavior, coauthor **Mike May** (below) who was





investigating the ability of insects to evade predatory bats. With the help of aeronautical engineer James DeLaurier and fighter pilot James E. Whinnery, they were able to outline the "top gun" aerial maneuvers of mantises pursued by bats. Yager plans to study the evolution of hearing in inse the tropics, which are the home of mantis species. May, who began w children's science stories while at Co is now a full-time science edito writer, a career he calls the "most fu that I could imagine." He is curren associate editor of *American Sci* magazine. For more information c ways insects evade bats, the author readers to Donald Griffin's *Listening Dark* (Ithaca: Cornell University 1986) and L. A. Miller's "How I Detect and Avoid Bats," in *Neuroeth and Behavioral Physiology,* edited Huber and H. Markl (Berlin: Spri Verlag, 1983).

Fred Bruemmer (page 54) goes to the ends of the earth to observe and photograph wildlife. A specialist in animals of the Arctic and Antarctic, Bruemmer has traveled to polar regions for the past thirty-five years. An independent naturalist and frequent contributor to *Natural History,* he is a native of Riga, Latvia, but has long made his home in Montreal. Bruemmer visited the Auckland Islands in the early 1980s with sea mammal biologist Martin Cawthorn to study the behavior of Hooker's sea lions, which breed there, and ended up studying the islands' skuas as well. "I had read about the extremely aggressive behavior of breeding skuas elsewhere," says Bruemmer, "and I was struck by the gentleness of the Enderby skuas toward humans." He also found that this



docility does not extend to the othe mal inhabitants of Enderby Is Bruemmer is currently on a three-m excursion to southern Australia to tinue his study of sea lions. For f reading, he recommends *The Skua* Robert W. Furness (Calton, Engla and AD Poyser, 1987).

xander S. Milovsky, a Moscow list-photographer, (page 34) has d extensively throughout the for- oviet Union, exploring and docu- g its little-known regional cultures. or staff writer until 1980 on the na- magazine *Kultura,* Milovsky has ed ten books on Eurasian religious ifices, and practices. Last July in *l History* Milovsky published a dra- irsthand account of a healing cere- by a Nganasan shaman in Siberia akou's Spirit Flight"). This time he from Moldova to Azerbaijan to five festivals connected with the



of winter and rebirth of spring. "To photographed only one of these he claims, "would be considered a for any Russian ethnographer. Sev- f them told me that these practices no r exist, although they are well known older accounts." For further reading, Festivals and Traditions of the Geor- Soviet Socialist Republic," in *Cul-* , vol. 3, no. 2, 1976, pp. 68–81.

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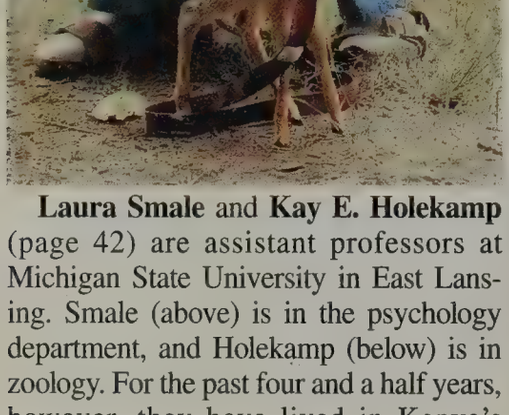
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Laura Smale and **Kay E. Holekamp** (page 42) are assistant professors at Michigan State University in East Lansing. Smale (above) is in the psychology department, and Holekamp (below) is in zoology. For the past four and a half years, however, they have lived in Kenya's Masai Mara National Reserve, studying free-living spotted hyenas. Smale and



Holekamp want to continue working with wild hyenas, but they also look forward to resuming their respective research projects with rodents. Smale's plans include studies of the neural and hormonal regulation of biological rhythms, as well as hormonal influence on aggressive behavior. Holekamp will return to the subject of her Ph.D. thesis—wild ground squirrels—and wild African grass rats, investigating their physiological ecology and dispersal. Smale and Holekamp are writing a lay book about their experiences studying the Mara hyenas, living in the bush, and interacting daily with their Masai neighbors. To learn more about hyenas, readers can turn to Hans Kruuk's *The Spotted Hyena* (Chicago: University of Chicago Press, 1972) and M. G. Mills's *Kalahari Hyenas* (London: Unwin Hyman, 1989).

After studying red foxes in Scotland and arctic foxes on the Aleutian Islands, **Laurence G. Frank** (page 46) turned his attention to spotted hyenas. In 1978 Frank (below) started the Masai Mara hyena study and spent much of the next six years in the field in Kenya. Together with Kay Holekamp and Laura Smale, he is still actively involved in that long-term population study, but the bulk of his time is now spent with a captive hyena colony at the University of California at Berkeley, where he is a research associate in the psychology department. **Stephen E. Glickman** (right), a professor in the same department since 1968, is director of the university's captive hyena project. Frank and Glickman find that while their re-





search energies are largely devote
derstanding the endocrinology an
differentiation in female spotted
they are sometimes called upon
more dramatically involved with
mals. In 1991, for example, ragi
near the colony forced them to e
the project's thirty hyenas to an
building on campus. Fortunately,
port, while spotted hyenas can b
rough on one another, they look o
searchers as their mothers and are
ably gentle. In fact, Frank says he
sometimes what might have happ
this highly sociable hyena had ev
close association with humans,
dog's ancestors did. What sort of d
pets might we have had then? For
siblicide, the authors recommend
Mock's May 1985 *Natural History*
"Knockouts in the Nest."

Photographed by his partner, Jean Stoick, **Carl R. Sams II**, this month's "Natural Moment" photographer (page 76) appears with two white-tailed deer. A native of Michigan, Sams began his career in wildlife photography in 1982 when he took a picture of three bucks in a forest near his home in White Lake, Michigan. Following that, Sams attracted a doe by offering her an apple, and a few days later, he was shaking the apple tree for the doe and her fawn. Over the years, Sams has taken more than 40,000 pictures of one deer family to whom his presence has become so familiar that Sams says, "Now I have nineteen deer that I can walk
the forest with." He and Stoick ha
developed a close relationship w
pair of common loons, which the
photographed for five summers. T
tience has paid off; their pictures h
peared in many magazines and w
merous awards. Sams explains
could not have taken the "Natur
ment" photograph of egrets fighti
had not anticipated the birds' be
which he had been observing for
He took the picture with a Nikon F
era with a 500mm lens at a shutte
of one 1/2,000 of a second.





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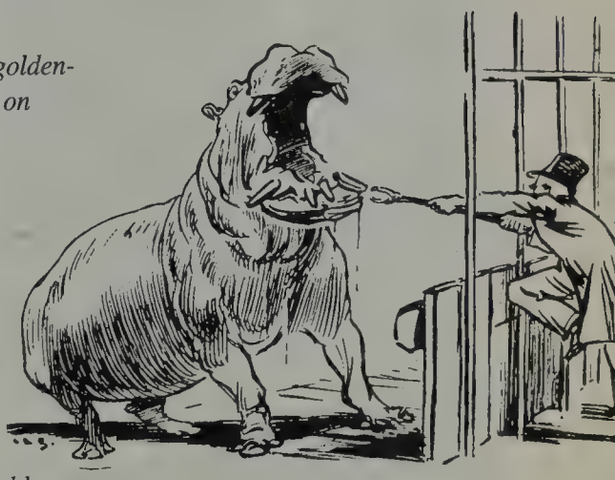
A WORLD DIFFERENT

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NATURAL HISTORY Vol. 102, No. 2, February 1993



COVER: *Partial to evergreens, a female golden-crowned kinglet perches in a spruce. Story on page 4. Photograph by Rob and Melissa Simpson; Simpson and Co., Nature Stock.*



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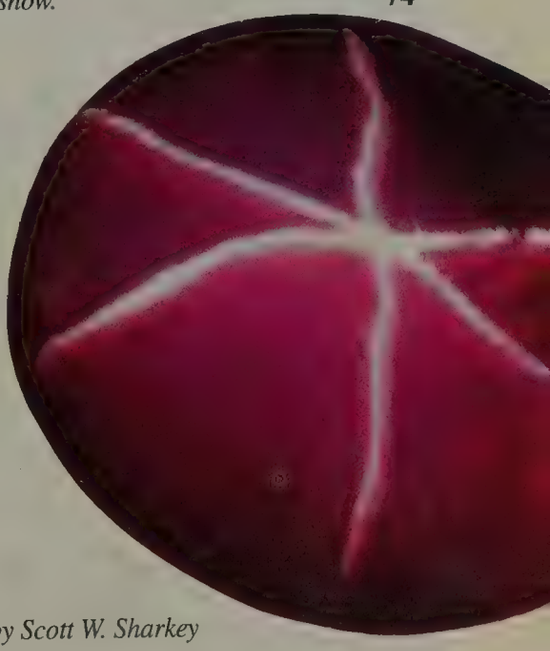
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LETTERS

JUST SO EGG STORIES

It surprises me that Stephen Jay Gould had such trouble finding anecdotal evidence among his American colleagues at Harvard for "Columbus Cracks an Egg" (December 1992). I recall with pleasure a day in my boyhood in Tulsa, Oklahoma, in the late 1940s when my parents took me to a movie entitled *Christopher Columbus.* The most vivid recollection I have from it was of Columbus posing the standing egg riddle to a haughty group of royal advisers; then, to their amazement, cracking the egg down hard on the table. It never has occurred to me since then that I was witnessing iconoclastic behavior or a bolt of creativity. Rather, I think I appreciated its bold empiricism; the egg—at least in the film—was hard-boiled.

BONHAM C. RICHARDSON
Virginia Polytechnic Institute
Blacksburg, Virginia

I was brought up in Belgium, where the story of Columbus and his egg was common knowledge, as it must have been in Darwin's time. The story's moral, however, was somewhat different. When Columbus's achievement was belittled at Cardinal Mendoza's banquet, Columbus asked the guests to stand an egg on its head. They could not figure out how to do this, and he showed them. When they complained that they all could do it that way, Columbus answered them: yes, of course you can, after I have shown you how. As to what Darwin meant in his reference to Columbus, I think he wanted to show how even the best mind could overlook the obvious.

Reading Gould is always challenging and fun, even when I find myself not agreeing. Long may he continue writing for *Natural History.*

ROBERT LUBELL
New York, New York

Stephen Jay Gould's "Columbus Cracks an Egg" reminds me that, just this once, I knew something he didn't. My story, which emanates from a distant childhood, has Columbus being taunted by fellow pilots after many voyag visited the Americas; they impli what Columbus had done was spectacular. In other words, sh across the Atlantic was easy, and bus's accomplishment did not dese adulation it received. Columbus th lenged his detractors to balance an its end. When they all failed, Co took an egg and gently cracked it table, and stood it on its newly fl bottom. It never occurred to me t was cheating or the mere use of a or expedient." The message as I se which Columbus is supposed to h fered to the scoffers, was that on have seen how something difficul complished, it may be very easy to the leader. This, I think, is the in and enduring scientific message Columbus tale and may well be wh win had in mind with his refere Columbus's egg.

LAWRENCE W
Redwood City, Ca

PHARAOHS AND FAROUK

I enjoyed Allen Guttman's artic Sports" (August 1992), which di how important it was for Eg pharaohs to prove their athletic p and the resultant stories of asto feats by these rulers. Guttman mig overlooked a possible explanat these reports.

Earlier in our own century, your Farouk of Egypt was sent to Engl schooling. When he presented hir tryouts for his school's boxing te announced that he had trained as in Egypt, where he was an und champion. He then entered the ri was thoroughly trounced by an classmate. Stunned, he explain Egypt, no one ever hit me back!"

Perhaps Farouk's Egyptian opp were upholding an ancient tradition

MYRON MOS
San Francisco, Ca

IN MOURNING

I was delighted to read Steph

s essay on Tennyson's *In Memo-*
"This View of Life," November
because the poem's imagery and in-
had been the focus of conversations
vith my father. Although commen-
n the medical and scientific content
Memoriam may hold our attention
I endorse Professor Gould's view
should be read for its powerful de-
ons of the experience of mourning
the author's emotional and philo-
al passage from grief to acceptance
rofound loss. A decade ago, while
near Bristol, England, I cycled to
Andrew's Church, Clevedon, to find
morial to Tennyson's friend, Arthur
n. From respect for the memory of
her, who had loved the majesty and
ry of *In Memoriam,* I reread the
in the quiet church and left much
t peace. Like my father before me,
ousands before him, I had found so-
Tennyson's *In Memoriam.*

ROD K. CALVERLEY
University of California
San Diego, California

WATER SOLUTION

as somewhat amused by Sokolov's
lations on saltwater immersion in
ry in a Stewpot" (November 1992).
ng small mammals in salt water be-
ooking is common among rural peo-
specially in the Midwest and South.
vater is considered to be an antisep-
moving bacteria, especially from ac-
tal contamination from feces and
during the dressing of the animal.
vater is also effective in removing
. Lastly, some soaking in salt water
ves the "wild taste." Having
ered and eaten one small goat, I can
to the need to eliminate that taste. I
ct that the people of Montserrat use
vater for the same reasons that the rest
"quaint country folk" do. I still wash
els in salt water, even though I am a
r educated yokel. Sometimes the
educated find too much mystery in
e things.

JACK RUSH
Vida, Montana



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Kinglets' Realm of Cold

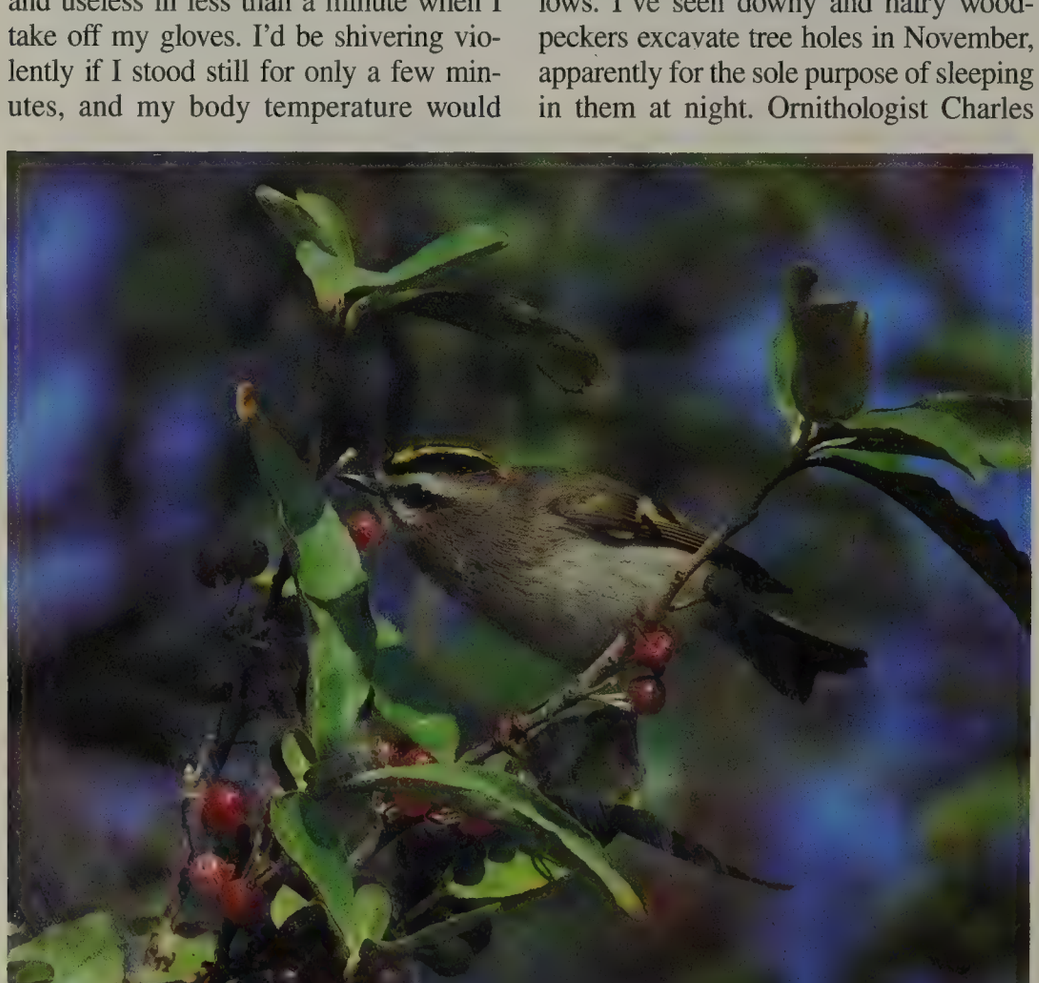
To survive New England winters, tiny birds must be fuel efficient

by Bernd Heinrich

On a midwinter night in the mountains of western Maine, the spruce-fir forest sounds like giant pounding surf as the wind drives thick snow through the trees. The thermometer reads –20° F, and bodily contact with the biting air is nearly lethal.

I'm clothed in insulated long underwear, wool pants covered by ski pants, two sweaters, a windbreaker, a woolen cap, gloves with liners, wool stockings, and insulated boots. My hands are immobilized and useless in less than a minute when I take off my gloves. I'd be shivering violently if I stood still for only a few minutes, and my body temperature would begin to drop unless I kept moving vigorously as well. How do the resident birds maintain a body temperature several degrees higher than ours, even for a minute? More amazingly, how do they survive the entire night?

Ruffed grouse escape the biting air by diving directly into the deep snow, hollowing out a temporary shelter for the night. Some chickadees and nuthatches seek refuge in ready-made tree holes and hollows. I've seen downy and hairy woodpeckers excavate tree holes in November, apparently for the sole purpose of sleeping in them at night. Ornithologist Charles Kendeigh has shown that sleeping t ties can aid overnight survival b heat is retained near the bird, and erable energy savings then result fr reduced need for shivering. Chic as shown by biologist Susan Chapl of Cornell, also save energy by a their body temperature to decline b 18° F. Most seed-eating birds, inc pine and evening grosbeaks, cro redpolls, goldfinches, and pine s show little nocturnal torpor, and the in these Maine winter woods only respective food trees bear ample packed with fat to fuel their near stant shivering throughout the nig key to survival is food, because converted to heat through shiv When food is scarce and shivering able, the bird may resort to torpor, b ing down the body's thermostat.



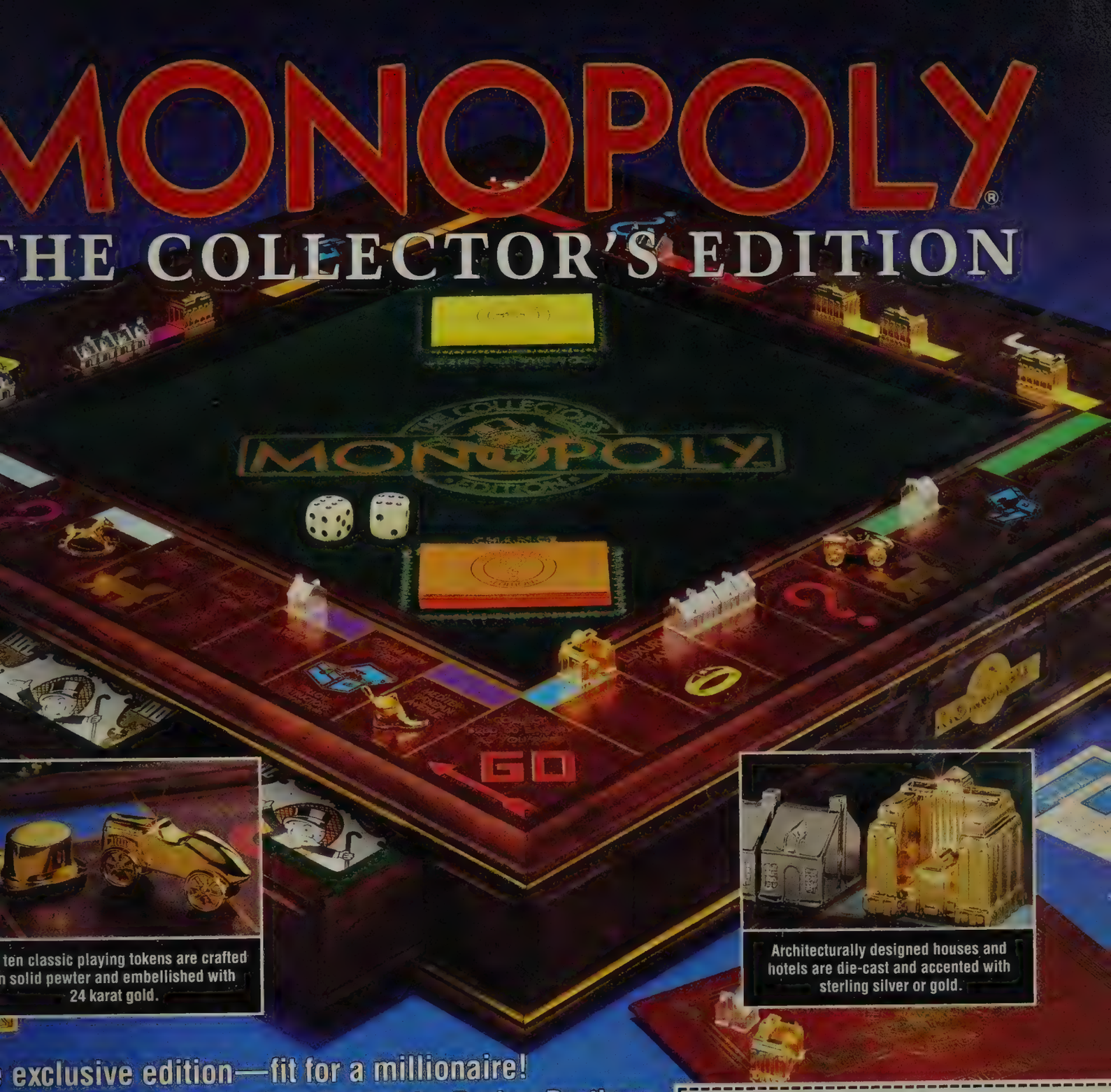
A golden-crowned kinglet gleans insects from the twigs of an autumn olive bush.
Harold Lindstrom

In a few days, the storm is almo gotten. For the survivors, life return usual routine. The grouse feed on buds, the finches fly in flocks fro seed-bearing tree to another, a pileated woodpecker again hamme and deep oval cavities into the base trees to extract hibernating carpente

Above the raucous "kek-kek-k the pileated woodpecker and the tsee" of the chickadee I hear a fai versation of golden-crowned kingle spruce thicket. Their sound is as un sive as a gentle breeze and just as goes unnoticed by all except thos know it. (I've talked with dozens of woodsmen who claim they have seen or heard them, although the bi among the most common in these w Among the thick branches, the tiny climb, hop, and hover as they f mainly on the undersides of Plumaged in soft olive, these bird crowns of gold bordered in blac males also have a flamelike orang

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that is normally concealed among the yellow crown feathers, but which can instantly be erected. The golden-crowned kinglet inhabits the coniferous forests of the northern United States and Canada year round. (A related species, the ruby-crowned kinglet, is here only in the summer.)

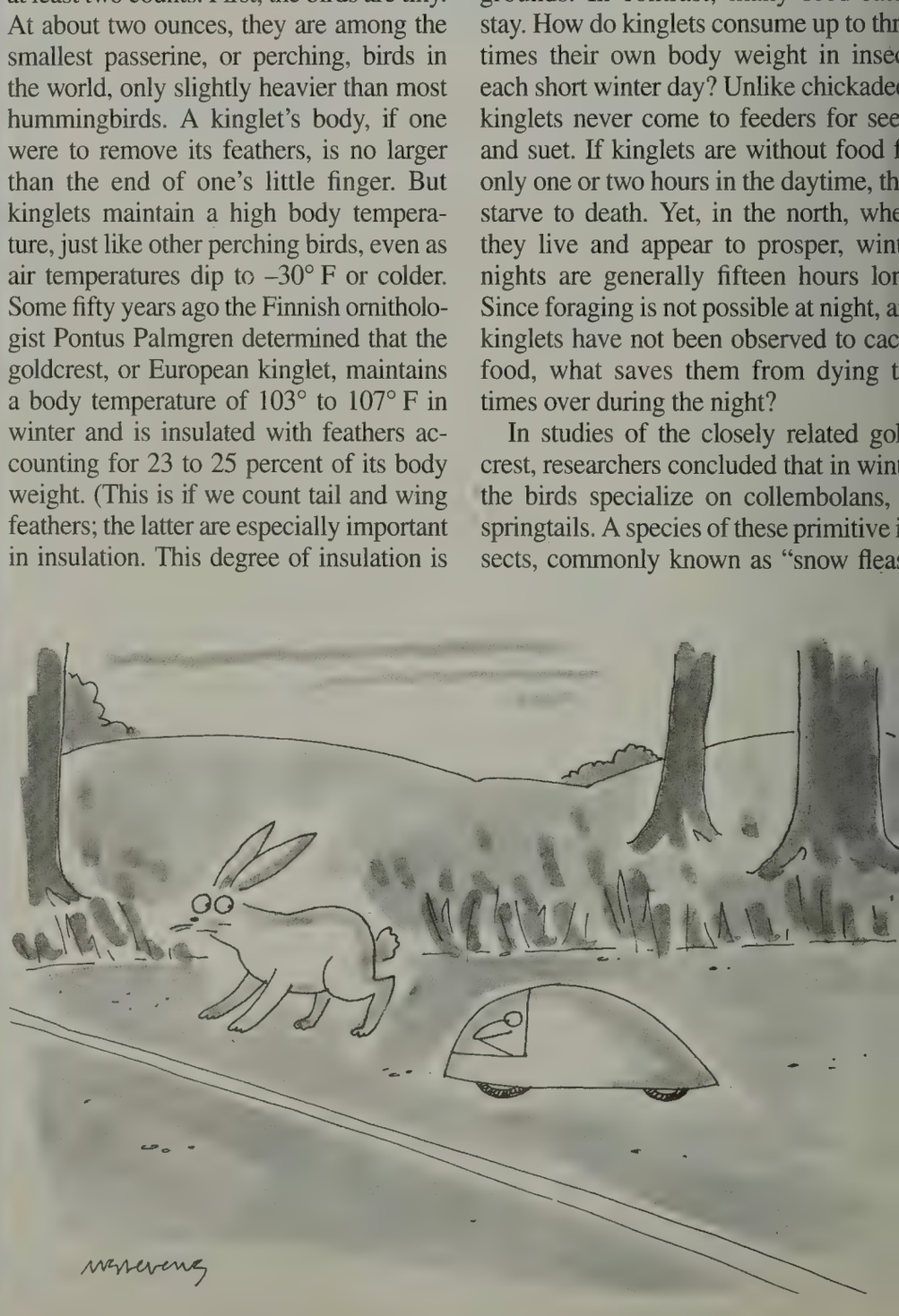
Evening shadows already were falling at 4:30 P.M., and I wanted to find out where the birds sleep. I was awed by their achievement of overnight survival in the cold. Three birds I was following suddenly made long, high-pitched calls, flew off as if on signal, and vanished. I was unable to find where or how they spend the night. However, the survivors of the storm a few nights earlier lingered in my mind.

The presence of kinglets in an area with recurrent subzero frosts is remarkable on at least two counts. First, the birds are tiny. At about two ounces, they are among the smallest passerine, or perching, birds in the world, only slightly heavier than most hummingbirds. A kinglet's body, if one were to remove its feathers, is no larger than the end of one's little finger. But kinglets maintain a high body temperature, just like other perching birds, even as air temperatures dip to –30° F or colder. Some fifty years ago the Finnish ornithologist Pontus Palmgren determined that the goldcrest, or European kinglet, maintains a body temperature of 103° to 107° F in winter and is insulated with feathers accounting for 23 to 25 percent of its body weight. (This is if we count tail and wing feathers; the latter are especially important in insulation. This degree of insulation is close to that of other northern birds rel tive to body size.)

According to the physical laws of hea ing and cooling, a two-ounce kingl should lose heat at about a 75 perce faster rate than does a four-ounce chic adee and would have to consume and bu 75 percent more food per unit of bo mass to maintain the same body temper ture. Also, since smaller birds have lesser absolute amount of insulation th do larger ones, they cool even faster th predicted by body mass alone. Noneth less, golden-crowned kinglets survive cold climates alongside the raven, t world's largest songbird.

A second notable fact about kingle winter residence in Maine is that they fe on insects. In the fall, most insectivoro birds migrate south, seeking better hunti grounds. In contrast, many seed-eate stay. How do kinglets consume up to thr times their own body weight in inse each short winter day? Unlike chickade kinglets never come to feeders for see and suet. If kinglets are without food f only one or two hours in the daytime, th starve to death. Yet, in the north, whe they live and appear to prosper, wint nights are generally fifteen hours lor Since foraging is not possible at night, a kinglets have not been observed to cac food, what saves them from dying t times over during the night?

In studies of the closely related gol crest, researchers concluded that in wint the birds specialize on collembolans, springtails. A species of these primitive i sects, commonly known as "snow flea



extremely abundant in the Maine ods, and I determined that the snow s spend their time on trees in the win- Might they be the manna on which the glets subsist? I examined the stomach tents of a dead kinglet at dusk. Tem- atures in the previous two weeks had n steadily below 0° F. The kinglet's mach was filled to capacity; it con- ned the remains of thirty-nine ometrid caterpillars, a spider, a few th scales, twenty-four almost micro- pic fly larvae, and just four springtails. While this probe showed that spring- s are not the birds' only food, it failed to ve the mystery of the kinglets' survival. hough the bird's stomach was packed h food, it could not have fueled heat duction for more than an hour or so on old night. Could most of the kinglets' ergy come from fat stores laid down oughout the day?

Charles R. Blem and John F. Pagels at rginia Commonwealth University as- ved body composition of golden- wned kinglets throughout the daylight iod in midwinter in Virginia. Body d, or fat, reserves increased from a low about 0.2 grams in the morning to about grams in the evening. Lipids have a h energy content, but using the stan- rd equations for maintenance metabo- n of birds of this size, Blem and Pagels dicted that a kinglet at normal body nperature accumulates no more than f the stores of lipid needed to fuel its tabolism through fifteen hours of night 32° F. Therefore, the fat stores accumu- ed during the day are not enough to ep a kinglet warm even on a relatively ld winter night. However, Ellen Thaler d her coworkers at the Alpenzoo in nsbruck, Austria, took a different ap- oach. Observing a slight difference in body weight of a bird between dusk d dawn, they calculated that if this ight loss is due to fat utilization, then ergy reserves suffice even at –13° F ring an eighteen-hour nocturnal fast. owever, the nocturnal weight loss is al- ost certainly not from fat alone. The rds lose weight from gut-emptying, as ll as glycogen, protein, and water loss.

Despite the unsolved mysteries of their ernight energy source and their food pply, the kinglets' survival strategies un- ubtedly include mechanisms of energy nservation. Kinglets conserve some dy heat by puffing out their feathers and cking in their twiglike legs and feet. As other birds, counter-current heat ex- angers probably play a prominent role in maintaining blood circulation through the extremities.

Do kinglets also stretch fat and energy supplies to last the whole night by becoming torpid? During torpor, the animal turns down its internal thermostat. Nocturnal torpor is generally a function of body size. The smaller the animal, the more energy it saves by hypothermia, and the quicker it can again warm up in the morning. Some hummingbirds go torpid regularly. A logical prediction would be that torpor is a key adaptation of kinglets, yet all the data so far available indicate that they do not go into torpor at night. Thaler has long studied kinglets in captivity, and her measurements of body temperature in outdoor aviaries show no steep drop in nighttime body temperature. Perhaps studies of wild birds, or of birds without access to ample aviary diets, will shed more light on this possibility. In terms of saving energy, it makes sense to enter torpor. But I suspect it is very dangerous if temperatures get too low. A small, cooled bird might be unable to regain thermal control and would freeze within minutes when air temperature dips below –15°F.

Behavior is also crucial in achieving nocturnal energy balance. Naturalists have observed that winter birds are almost absurdly tame at very low temperatures; they become oblivious to distractions and even to predators. So, too, with kinglets. They spend less time avoiding predators, moving about, and aggressively displaying, and they spend more time concentrating on feeding.

Another critical behavioral response is finding a good nocturnal shelter, which is why I tried to follow the birds at dusk to find out where they go. We know almost nothing about where wild kinglets spend the night, except that they likely seek shelter in dense conifer branches, often in little caves formed by snow cushions on these branches. Even a little shelter may make the difference between death and survival when near the edge. Do kinglets preferentially perch in the lower portions of thick trees where there is less wind current and convection? Do they fly to a preselected place when I see them suddenly leave at dusk? Blem has also observed these departures and once chanced to see a kinglet enter a squirrel's nest at dusk.

One very critical aspect of the microenvironment where kinglets spend the night is the availability of other warm bodies of their own kind. Studies have shown that at 32° F, pairs of roosting European goldcrests reduce their heat loss by 23 per-



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cent, and trios reduce heat loss by about 37 percent.

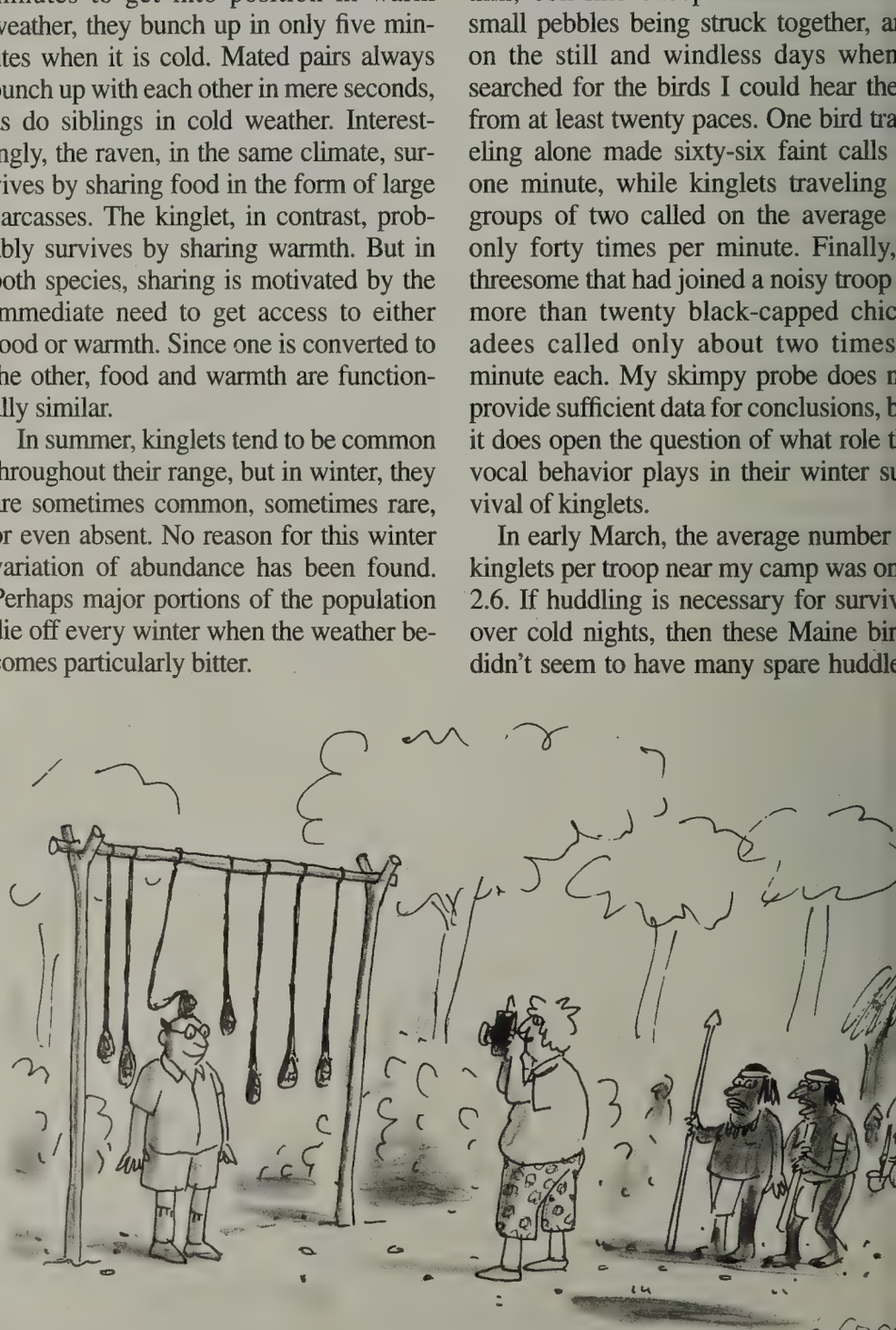
Just before dark, European goldcrests form groups with the aid of contact calls. Thaler observed that when approaching their sleeping tree, the birds make specific calls, which presumably attract the members of the troop, a number of kinglets foraging together. A second assembly, or bunching, call draws the group into a cluster along a horizontal branch where they will spend the night. Birds in the center of clusters sit bunched with their heads pulled into their shoulders and their bills pointing up, while the birds at the edges hold their heads to the sides. The contact groups form in warm weather as well as cold, but whereas it may take them twenty minutes to get into position in warm weather, they bunch up in only five minutes when it is cold. Mated pairs always bunch up with each other in mere seconds, as do siblings in cold weather. Interestingly, the raven, in the same climate, survives by sharing food in the form of large carcasses. The kinglet, in contrast, probably survives by sharing warmth. But in both species, sharing is motivated by the immediate need to get access to either food or warmth. Since one is converted to the other, food and warmth are functionally similar.

In summer, kinglets tend to be common throughout their range, but in winter, they are sometimes common, sometimes rare, or even absent. No reason for this winter variation of abundance has been found. Perhaps major portions of the population die off every winter when the weather becomes particularly bitter.

Heavy winter losses could be counte balanced by the exceptional numbers young that kinglets produce each yea Every year a pair produces two clutche each clutch containing seven to twel young. (Pairs usually build their secon nest before the first clutch has fledged Thus, only a small fraction of winter su vivors could account for a substantial ne population the next fall.

I was curious to find out if, in the –20° temperature, the kinglets near my Mai camp had survived. In a total of twenty-s hours that I looked for them in Februa and March, I encountered eighteen them (in seven troops). I doubt that I ove looked any kinglets nearby, because t birds vocalize almost constantly. The thin, bell-like cheeps reminded me small pebbles being struck together, a on the still and windless days when searched for the birds I could hear the from at least twenty paces. One bird tra eling alone made sixty-six faint calls one minute, while kinglets traveling groups of two called on the average only forty times per minute. Finally, threesome that had joined a noisy troop more than twenty black-capped chic adees called only about two times minute each. My skimpy probe does n provide sufficient data for conclusions, b it does open the question of what role t vocal behavior plays in their winter su vival of kinglets.

In early March, the average number kinglets per troop near my camp was on 2.6. If huddling is necessary for survi over cold nights, then these Maine bir didn't seem to have many spare huddle



"If they don't buy anything, I say we kill them."

rby. Body warmers are not likely to ap-
r magically just at dusk. Perhaps the
glets' sociability throughout the day
ps to insure the presence of huddlers on
d nights. Attracting and keeping con-
t with others may be a key component
winter survival, one that is not likely to
maintained by vision alone in the dense
niferous forests. With an average of
y 2.6 birds per troop, losing one or
re members might doom the rest in the
t period of heavy frost or food depriva-
n. Silent birds will not be followed.
ey must themselves follow (which
ld take time from their own precious
aging) or become isolated. By calling
y can both follow and be followed.

Knowing that these wraiths of the forest
re still here despite the subzero weather
s reassuring. But as I retired to the
rmth of my cabin the night of March 3,
gain heard gusts of wind that moaned
ough the woods and shook the cabin.
ins pummeled the roof all night. Bone
y under three blankets, I wondered how
kinglets were faring, being drenched in
open or whipped by the wind as they
ddled under some spruce bough.

When I awoke the next morning realiz-
g that there was still at least a month of
nter to go, I heard the trees creaking.
ey were glazed in ice. The freezing rain
ntinued throughout the day; the tree
nbs drooped lower and lower until many
me crashing down to the ground. Would
birds still be there next week?

On March 17, I was finally reassured
at they would again populate the sum-
er woods. The sun shone, and the snow,
ll two feet deep in some spots, was heav-
crusted and easy to walk on. Wood-
ckers drummed, and two ravens ca-
ened in a wild chase over the valley.
hen I heard the song of a golden-crowned
nglet, a rapid cascade of a dozen pure,
brant notes crammed into a mere second
d repeated six to nine times a minute.
he kinglet knew that the time for
ourtship had returned. Despite early
pril snowstorms, the kinglets' deep nest
ps of fine moss and lichens, cobwebs,
d snowshoe hare fur would again be
ade high in the spruce boughs and filled
ith two layers of tiny eggs.

ernd Heinrich, a professor of zoology at
e University of Vermont, is spending a
ear studying wildlife in the Maine woods.
is latest book, The Hot-Blooded Insects:
Mechanisms and Evolution of Ther-
noregulation, *will be published this*
pring by Harvard University Press.

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Rediscover Your World

Cordelia's Dilemma

Silence, though usually undervalued, can be golden

by Stephen Jay Gould

While Goneril and Regan jockey for their father's wealth by proclaiming their love for him in false and fulsome tones, Lear's third daughter, Cordelia, fears the accounting that her father will soon demand: "What shall Cordelia do? Love, and be silent...since, I am sure, my love's more ponderous than my tongue."

Lear then forces Cordelia into this game of ever more elaborate professions of love: "What can you say to draw a third more opulent than your sisters?" When the honorable Cordelia, refusing to play falsely for gain, says nothing, Lear cuts her off from all inheritance, proclaiming that "nothing will come of nothing."

Lear's tragic error, which shall lead to blinding, madness, and death, lies in not recognizing that silence—overt nothing—can embody the deepest and most important meaning of all. What, in all our history and literature, has been more eloquent than the silence of Jesus before Pilate, or Saint Thomas More's date with the headsman because he acknowledged that fealty forbade criticism of Henry VIII's marriage to Anne Boleyn, but maintained, literally to the death, his right to remain silent and not to approve?

The importance of negative results—nature's apparent silence or nonacquiescence to our expectations—is also a major concern in science. Of course, scientists acknowledge the vitality of a negative outcome and often try to generate such a result actively—as in trying to disprove a colleague's favored hypothesis. But the prevalence of negative results does pose an enormous, and largely unaddressed, problem in the reporting of scientific information. I do not speak of fraud, cover-up, finagling, or any other manifestation of pathological science (although such phenomena exist at a frequency that, in all honesty, we just do not know). I refer, rather, to the all too wonderfully human love of a good tale—and to our simple and utterly reasonable tendency to shun the inconclusive and the boring.

The great bulk of daily scientific work never sees the light of a published day (and who would wish for changes here, as the ever-increasing glut of journals makes keeping up in one's own field impossible and exploration of others inconceivable?). Truly false starts are deposited in circular files—fair enough. But experiments fully carried forth and leading to negative results end up, all too often, unpublished in manila folders within steel-drawer files, known only to those who did the work and quickly forgotten even by them. We all know that thousands of novels, considered substandard by their authors, lie in drawers throughout the world. Do we also understand that even more experiments with negative results fill scientific cabinets?

Positive results, on the other hand, tell interesting stories and are usually written up for publication. Consequently, the available literature may present a strongly biased impression of efficacy and achieved understanding. Such biases, produced by the underreporting of negative results, do not only permeate the arcana and abstractions of academic science. Serious, even tragic, practical consequences often ensue. For example, spectacular medical claims for the efficacy of certain treatments (particularly for chronic and fatal illnesses like cancer and AIDS) may be promulgated after a single positive result (often obtained in a study based upo a very small sample). Later and larg studies may all fail to duplicate the pos tive results, effectively disproving th value of the treatment. But these subs quent negative results often appear only highly technical journals read by more r stricted audiences and, as nonstories, d not so readily attract the attention of th media—and people may continue t squander hope and waste precious tim following useless procedures.

Statistics often get a bum rap in our e ithets and editorials. But I am both a chan pion and a frequent user of statistical pr cedures, for the science exists largely identify and root out hopes and misperce tions falsely read into numerical data. St tistics can tell us when published numbe truly point to the probability of a negati result, even though we, in our hopes, hav mistakenly conferred a positive interpret tion. But statistics cannot rescue us whe we hide our nonlights under a bushel (wi apologies to Matthew 5:15)—that is, whe we only publish positive results and co sign our probable negativities to no scrutiny in our file drawers.

I had thought about this problem a gre deal (especially when writing *The Mi measure of Man*), but I had not realize that this special sort of bias had both name and a small literature devoted to i weighty problems, until I came upon paper by Colin B. Begg and Jesse A Berlin entitled "Publication bias: a pro lem in interpreting medical data" (*Journ of the Royal Statistical Society,* vol. 15 1988, pp. 419–63).

Begg and Berlin begin their paper wi a wonderful quotation from Sir Franc

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by Robert Lyn Nelson

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Bacon (*The Advancement of Learning*, 1605) on the tendency to publish only positive results that tell good stories:

> For as knowledges are now delivered, there is a kind of contract of error between the deliverer and the receiver; for he that delivereth knowledge desireth to deliver it in such form as may be best believed, and not as may be best examined; and he that receiveth knowledge desireth rather present satisfaction than expectant inquiry.

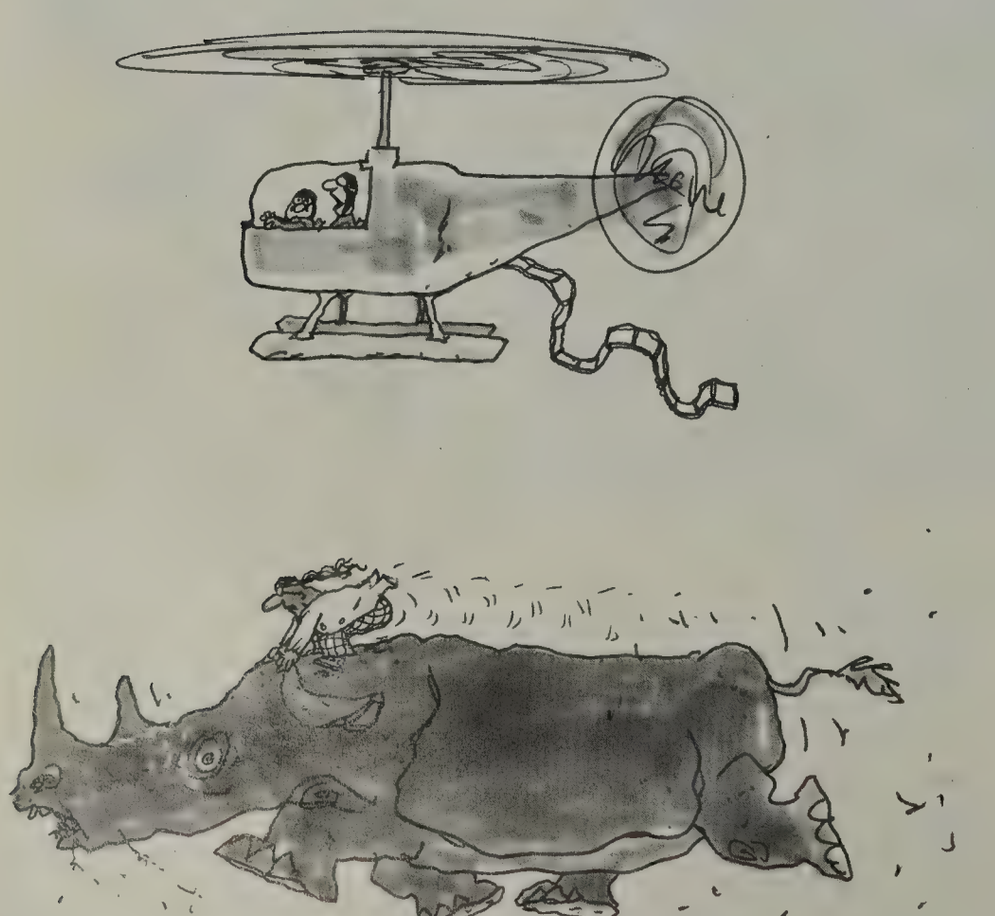
Begg and Berlin then cite several documented cases of publication bias. We can hardly doubt, for example, that a correlation exists between socioeconomic status and academic achievement, but the strength and nature of this association represent important information for both political practice and social theory. A 1982 study by K. R. White revealed a progressively increasing intensity of correlation with the prestige and permanence of the published source. Studies published in books reported an average correlation coefficient of 0.51 between academic achievement and socioeconomic status; articles in journals gave an average of 0.34, while unpublished studies yielded a value of 0.24. Similarly, in a 1986 article, A. Coursol and E. E. Wagner found publication bias both in the decision to submit an article at all, and in the probability of its acceptance. In a survey of outcomes in psychotherapy, they found that 82 percent of studies with positive results lead to submission of papers to a journal, while only 43 percent of negative outcomes provoked an attempt at publication. Of papers submitted, 80 percent reporting positive outcomes were accepted for publication, versus only 50 percent of papers claiming negative results.

My favorite study of publication bias is the book-length *Myths of Gender* by Anne Fausto-Sterling, a unique and important contribution to the literature of feminism for this reason. In tabulating claims in the literature for consistent differences in cognitive and emotional styles of men an women, Fausto-Sterling does not den that genuine differences often exist, and i the direction conventionally reported. Bu she then, so to speak, surveys her co leagues' file drawers for studies not pub lished, or for negative results publishe and then ignored, and often finds that great majority report either a smaller an insignificant disparity between sexes o find no differences at all. When all studie those not published as well as those pub lished, are collated, the much-vaunted di ferences often devolve into triviality. Na ural history, after all (as I have argued s often in these essays), is preeminently study of relative frequency, not of absolu yeses or noes. If a claim based on pub lished literature states that "women in a studies strongly…"—and the addition o unpublished data changes that claim to "i a minority of studies, a weak effect sug gests that women…"—then meaning is e fectively reversed (even though positiv outcomes, when rarely found, show a con sistent direction.)

For example, a recent favorite in po psychology (although waning of late, think), has attributed different cognitiv styles in men and women to the less late alized brains of women (less specializa tion between right and left hemispheres o the cerebral cortex). Some studies have in deed reported a small effect of greate male lateralization; none has found mor lateralized brains in women. But most ex periments, Fausto-Sterling found, de tected no measurable differences in late alization—and this is the dominan relative frequency (even in published lite ature) that should be prominently re ported, but tends to be ignored as "n story."

Publication bias is serious enough in i promotion of a false impression based on small and skewed subset of the total num ber of studies. But at least the right que tions are being asked and negative resul can be conceptualized and obtained— even if they then tend to be massively un derreported. But consider the far more in sidious problem closer to Cordelia dilemma with her father: what if our con ceptual world excludes the possibility o acknowledging a negative result as a phe nomenon at all? What if we simply can see, or even think about, a different an meaningful alternative?

Cordelia's plight is a dilemma in the li eral sense—a choice between two equall undesirable alternatives: she either re mains honorable, says nothing, and incu



"Dr. Montauk forgot the knockout shots."



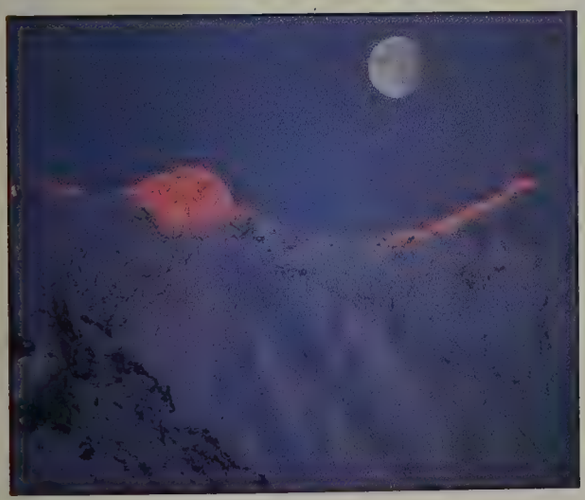
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her father's wrath; or she plays an immora game to dissemble and win his affection She tumbles into this plight because Lea cannot conceptualize the proposition tha Cordelia's silence might signify he greater love—that nothing can be th biggest something.

Cordelia's dilemma is deeper and mor interesting than publication bias, as w glimpse the constraining role of neurolog ical, social, and psychological condition ing in our struggle to grasp this comple universe into which we have been so re cently thrust. Publication bias is only guard at the party door giving passage t those with the right stamp on their hands At least the guard can see all the peopl and make his unfair decisions. Those re jected can gripe, foment revolution, c start a different party. The victims c Cordelia's dilemma are "unpersoned" i the most Orwellian sense. They are resi dents in the last gulag in inaccessibl Siberia, the last outpost of Ultima Thul They are not conceptualized and therefor do not exist as available explanations.

These two forms of nonreporting hav different solutions. Publication bias de mands, for its correction, an explicit com mitment to report negative results that ap pear less interesting or more inconclusiv than the "good story" of positive ou comes. The solution to Cordelia' dilemma—the promotion of her nothing t a meaningful something—cannot be re solved from within, for the existing theor has defined her action as a denial or non phenomenon. A different theory must b imported from another context to chang conceptual categories and make her re sponse meaningful. In this sense Cordelia's dilemma best illustrates the dy namic interaction of theory and fact in sc ence. Correction of error cannot alway arise from new discovery within an ac cepted conceptual system. Sometimes th theory has to give first, and a new frame work be adopted, before the crucial fact can be seen at all. We needed to suspec that evolution might be true in order to se variation among individuals in a popula tion as the dynamic stuff of historica change and not as trivial or accidental de viation from a created archetype.

I am especially interested in Cordelia dilemma, and its resolution by using ne theories to promote previously ignore phenomena to conceivability and interes because the "main event" of my early ca reer included an example that taught me great deal about the operations of science Before Niles Eldredge and I proposed th

ory of punctuated equilibrium in 1972, stasis, or nonchange, of most fossil ecies during their lengthy geological espans was tacitly acknowledged by all eontologists, but almost never studied plicitly because prevailing theory ated stasis as uninteresting nonevidence nonevolution. Evolution was defined gradual transformation in extended fos- sequences, and the overwhelming evalence of stasis became an embarrass- feature of the fossil record, best left ig- red as a manifestation of nothing (that nonevolution).

My own thesis advisor had mastered tistics in the hopes of detecting a subtle adualism that was not visually evident in ssil sequences. He applied his tech- ques to some fifty brachiopod lineages Silurian rocks of the Michigan Basin, und no evidence for gradual change (but sis in all lineages with one ambiguous ception), considered his work a disap- intment not even worth publishing, and t the field soon thereafter (for a brilliant reer in another domain of geology, so r loss was their gain).

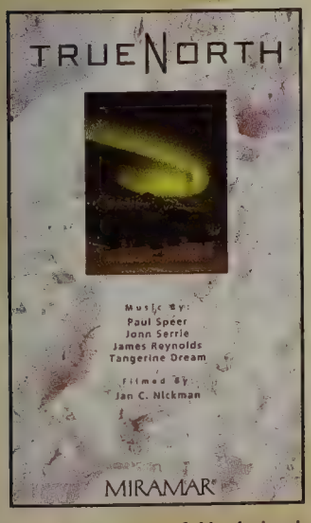
But Eldredge and I proposed that stasis ould be an expected and interesting rm, and that evolution should be con- centrated in brief episodes of branching speciation. Under our theory, stasis became interesting and worthy of documentation—as the norm that rare events of change disrupt. We took as the motto of punctuated equilibrium: stasis is data. (One might quibble about the grammar, but I think we won the conceptual battle.)

Punctuated equilibrium is still a subject of lively debate, and some (or most) of its claims may end up on the ash heap of history, but I take pride in one success relevant to Cordelia's dilemma: our theory has brought stasis out of the conceptual closet. Twenty-five years ago, stasis was a non-subject—a "nothing" under prevailing theory. No one would have published, or even proposed, an active study of lineages known not to change. Now such studies are routinely made and published, and we have a burgeoning literature to document the character and extent of stasis in quantitative terms.

Punctuated equilibrium is a theory about the origin and history of species. That is, the stability of individual species represents the "nothing" that our theory emphasized to attract the attention of researchers. A different kind of "nothing" permeates, and also biases, our consideration of the next most inclusive level of evolutionary stories—the history of phyletic bushes, or groups of species sharing a common ancestry: the evolution of horses, of dinosaurs, of humans, for example. This literature is dominated by the study of trends—directional changes through time in average characteristics of species within the bush. Trends surely exist in abundance, and they do form the stuff of conventional good stories. Brain size does increase in the human bush; and toes do get fewer, and bodies bigger, as we move up the bush of horses.

But the vast majority of bushes display no persistent trends through time. All paleontologists know this, but few would ever think of actively studying a bush with no directional growth. We accept that the history of continents and oceans presents no progressive pattern most of the time—"the seas come in and the seas go out" in an old cliché of geology teachers from time immemorial. But we expect life's bushes to grow toward the light, to tell some story of direction change. If they do not, we do not feature them in our studies—if we even manage to see them at all. We cannot accept for life the preacher's assessment of earthly time (Ecclesiastes

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1:9): "The thing that hath been, it is that which shall be; and that which is done, is that which shall be done; and there is no new thing under the sun."

Yet we must study bushes with no prominent directional change if we are to gain any proper sense of the full range and character of life's history. Even if we believe (and I will confess to holding this conventional bias myself) that trends, however rare, are the most interesting of phyletic phenomena—for they do supply the direction that makes evolution a pageant rather than a tableau—we still need to know the relative frequency of nonprogressive evolution, if only to grasp the prevailing substrate from which rare trendiness builds interesting history. How can we claim to understand evolution if we only study the percent or two of phenomena that construct life's directional history and leave the vast field of straight-growing bushes—the story of most lineages most of the time—in a limbo of conceptual oblivion?

I see some happy signs of redress, as paleontologists are now beginning to study this higher order stasis, or nondirectional history of entire bushes. An excellent and path-breaking case has just been published by Ann F. Budd and Anthony G. Coates in our leading trade journal, *Paleobiology* (vol. 18, 1992, pp. 425-46): "Nonprogressive evolution in a clade of Cretaceous *Montastraea*-like corals." Budd and Coates state their aim in their introduction and I could not agree more:

> Just as the study of stasis within species has facilitated understanding of morphologic change associated with speciation, we show that study of nonprogressive evolution of fers valuable insight into how the causes of trends interact and thereby produce complex evolutionary patterns within clades [evolutionary bushes], regardless of the overall direction.

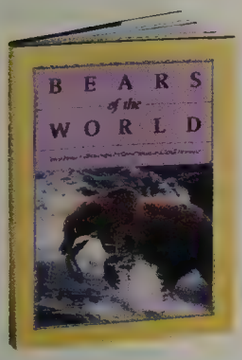
Montastraea is a genus of massive colonial reef-building corals, still important in our modern faunas (many readers undoubtedly have a chunk of *Montastraea* on their mantle pieces). Budd and Coates studied the earlier history of the *Montastraea* bush during the long span of Cretaceous time—some 80 million years duration, and representing the last period of dinosaurian domination on land. They found little evidence of directional change, but rather a story of oscillation within a range set by minimal and maximal size of corallites (individual coral animals within the colony). At one end "large-corallite" species (3.5–8.0 mm in diameter) are more efficient in removal of sediment and tend to be more common in regions of turbid water; at the other end "small-corallite" species (2.0–3.5 mm in diameter) tend to dominate in clearer waters near the reef crest. In addition, large corallite species tend to feed actively on small planktonic animals, while small corallite species derive more nutrition directly from the zooxanthellae (photosynthetic algae) that live symbiotically within their tissues.

Budd and Coates conjecture that coralite diameters may be held within these limits by some ecological or developmental constraint at the low end (implying that still smaller corallites could neither develop nor function adequately) and by a limit to the number of septa at the high end. (Septa are the radiating series of plates that form the skeletal framework for a corallite. The "astraea" in *Montastraea* refers to the star-shaped pattern of these radiating septa in cross section.) The size of corallites might be limited if new septa could not form beyond a certain number—although this argument is frankly speculative. If such constraints limit the domain of corallite form, and if each end enjoys advantages in different environments and ways available in some parts of the geographic range, then evolution might just oscillate back and forth, with no persistent directional component through time.



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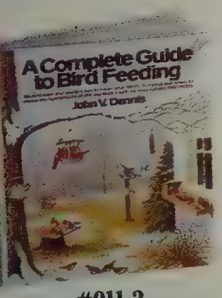


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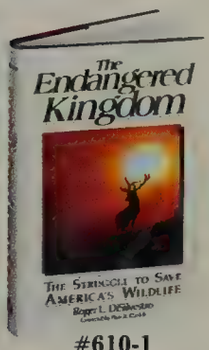
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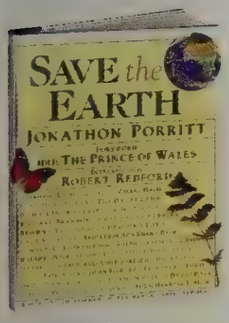
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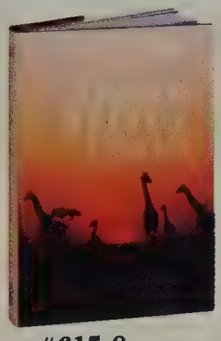
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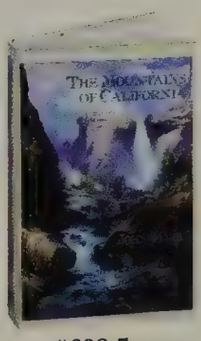
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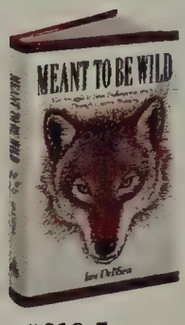
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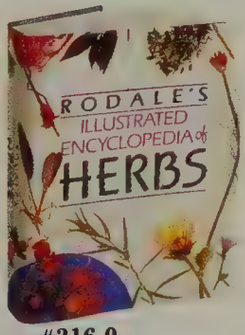
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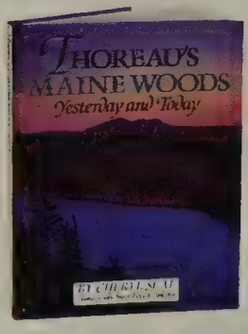
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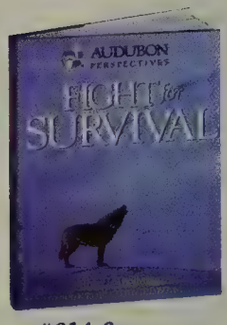
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Budd and Coates found just such an oscillation, hence their well-chosen title of "nonprogressive evolution." They divided the Cretaceous into four intervals and then traced the pattern of species changes through these times (most of their long paper presents technical details of defining species and inferring genealogical connections among them). They found that the transition from interval one to interval two featured a differential production of small-corallite species from large-corallite ancestors and a southward spread of the bush's geographic range. "Limited speciation and stasis" then predominated within intervals two and three. Later, between intervals three and four, large-corallite species tended to radiate from small-corallite ancestors as the bush became restricted in range to the Caribbean. The end, in other words, did not leave the bush very different from its beginnings—the seas came in and the seas went out, and *Montastraea* oscillated between prevalence of small- and large-corallite species within its restricted range. And so it goes for most groups in most long segments of geological time—lots of evolutionary change, but no story of clear and persistent direction.

I do feel the force of Cordelia's dilemma as I write these words. Budd and Coates's article inspired me to write this essay. Yet my description of their results occupies only a small portion of this text because nondirectional evolution doesn't provide the stories that stir our blood and incite our interest. This is the bias of literary convention that we must struggle to overcome. How can we interest ourselves sufficiently in the ordinary and the quotidian? Nearly all of our life so passes nearly all the time (and thank goodness for that, lest we all be psychological basket cases). Shall we not find fascination in the earth's daily doings? And how can we hope to understand the rarer moments that manufacture history's pageant if we do not recognize and revel in the pervasive substrate?

No one has illustrated the dilemma better than Cordelia and Lear themselves, in their last appearance as prisoners in act scene 3. They are about to be taken awa and Lear, through the veil of madnes speaks of forthcoming time in jail, mad almost delightful by the prospect of tellin stories in the heroic and directional mod

> Come, let's away to prison:
> …so we'll live,
> And pray, and sing, and tell old tale
> and laugh
> At gilded butterflies, and hear poo
> rogues
> Talk of court news; and we'll talk wi
> them too,
> Who loses and who wins, who's in, ar
> who's out;
> And take upon's the mystery of thing
> As if we were God's spies: and we'
> wear out
> In a walled prison, packs and sects
> great ones
> That ebb and flow by the moon.

Sean O'Casey said that "the stage mu be larger than life," for how can we mak adequate drama from the daily doings shopping, eating, sleeping, and urinatin (in no particular order). If this be so, the our biases in storytelling augur poorly f an adequate account of life's real histor for how shall we ever promote the "noti ing" that surrounds us to adequate fascin tion for notice and documentation? B then, one of O'Casey's countrymen solve this problem in the greatest novel of th twentieth century. James Joyce's *Ulysse* treats one day in the life of a few ordinar people in 1904, yet no work of literatu has ever taught us more about the nature humanity and the structure of though May I then close with a kind of literar sacrilege and borrow the famous last lin of *Ulysses* for a totally different purpos Molly Bloom, in her celebrated soliloqu is, of course, speaking of something e tirely different! But her words make good answer to a pledge we should a take: Shall I promise to pay attention to th little, accumulating events of daily life ar not treat them as nothing against the ra and grandiose moments of history? "yes said yes I will Yes."



Stephen Jay Gould teaches biology, geo ogy, and the history of science at Harva University.

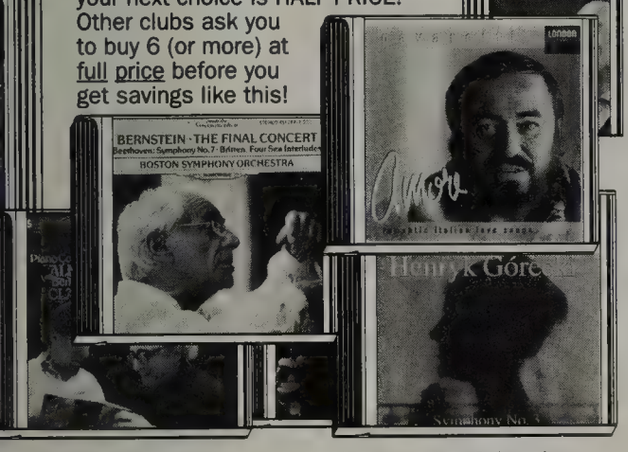
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Of Light Bulbs and Shaggy Dogs

Is laughter a universal language?

by Roger L. Welsch

Ask any American, especially one younger than fifty, to tell you a joke today, and you will almost certainly get a short question that has a short, funny answer. That's the modern idea of a joke. How many psychiatrists does it take to screw in a light bulb? (One, but he really has to want to.) Why did the chicken cross the road? (To see a man lay a brick.) That sort of thing.

Seventy-five years ago (and leaving aside tall tales), a joke was understood to be a narrative told in such a way that it excited laughter, often as much in the manner of its telling as in its conclusion. Jokes in the first half of this century could be as long as five or ten minutes and were often funny by virtue of the dialect—real or imagined—in which the tale was told: Irish, German, southern English, rural American.

A typical example of the genre (in an exaggerated rural drawl) went like this:

This hyar farmer goes to the big city and he tells his hired man Buford that he's a-gonna be in charge of everything for a couple o' days so he should do what he can to keep everything under control. This hyar farmer goes through a long list o' chores for ol' Buford, ending up with a long warning that he should be especially careful to keep an eye on the farmer's favorite pet cat.

The farmer rings Buford up on the party line the next day asks how things are doing on the farm and Buford blurts out, "Boss, your cat done died."

"Oh no! What a blow! That's terrible!" the farmer gasps. "My God, Man, couldn't you have used a little diplomacy and compassion and broke the bad news to me kinda gentle-like? Oh, this is terrible news! Terrible!"

The hired man mumbles around a while and finally asks the farmer what he means by this diplomacy and compassion stuff. "Well, you should-a started off sort of easy, by telling me maybe that the cat got stuck up on the roof, and that you tried to get her down, and that she fell, and was badly hurt, and later, mercifully, passed away."

The hired man assured him that he now understood and would be more careful in the future. "Fine," said the farmer. "Tell me, how did the cat die?"

"Well," the hired man says, "she was run over by one of the fire trucks."

"Fire trucks?" the farmer stuttered. "What fire trucks?"

"The ones that came to put out the fire in the barn."

"HOW DID THE BARN CATCH ON FIRE?"

"Well, it took hold when the fire swept in from the corn field."

"FIRE IN THE CORN FIELD?!"

"The one that started when the tractor exploded."

By this time, of course, the farmer is completely distraught—sobbing, gasping, sputtering. "What about my wife? Is she all right? How is she taking all this?"

There is a long pause from the other end of the telephone, and then the hired man begins tentatively, "Well, sir, your wife, she was stuck up there on the roof and..."

Not very many Americans today are willing to sit still and listen to a long story, no matter how funny it is. These days a joke is one or two set-up lines and a punch line, and that's it: Did you hear they found Jimmy Hoffa? (Under Tammi Faye Bakker's make-up!) Want to double the value of your Yugo? (Fill the gas tank.)

The only long story one hears today is the shaggy dog story, or "groaner"—a painfully long story that concludes with a painful pun. It is a parody of a joke, too long, and not all that funny, the exact opposite of what a joke in 1992 "ought t be." I have shortened up the followin story just to lessen the pain, so try to imag ine it told with a lot more detail, the narra tor pausing now and then to laugh at hi own goofy joke:

Quasimodo, the hunchback of Notr Dame, decides that he has been workin far too hard far too long and that he need a vacation. He goes to the priest of th cathedral, but the priest explains tha everyone who comes to the famou church expects to see the famous Quasi modo. No substitute will do, unless Mr. Q can find an exact double for a temporar replacement.

Quasimodo goes out to walk the street of Paris to think about the problem an darned if he doesn't run into a guy who i his exact mirror image. Quasimodo is ec static, of course, and explains hi dilemma. The other guy agrees to take th job for a few weeks, if only the Maste himself will teach him how to ring th great bells in the cathedral tower.

Quasimodo takes his replacement to th tower and demonstrates his technique: h takes a long, powerful, leaping run an smashes his head into one of the bells which rings with impressive resonance BA-WONG!!! The new guy decides i shouldn't be much of a problem, so h takes a run and bangs his head into th bell. Nothing. Just a dull thud. CLUNK!

"Maybe you need a longer run," Quasi modo suggests. So the replacement ringe takes a longer run. Still nothing. THUD He takes an even longer run and shows a little improvement. Finally the guy really backs up, backs up, backs up...and falls over the railing, down, down, down, an smashes onto the cathedral steps fa below.

Tourists rush up to see what has hap pened and find the poor man crumpled in a



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heap, dead as a doornail. "Who is this guy anyway?" one asks.

"I don't know," a second says. "His face sure doesn't ring a bell."

"Maybe not," opines a third. "But he's a dead ringer for Quasimodo."

See why they are called "groaners?" And that's one of the funny ones!

Not only has the style of American humor changed over the past century, so too has its content. For example, fifty years ago jokes with even the most modest sexual content were considered obscene and were restricted to word-of-mouth or were privately published in narrowly-circulated pulp magazines and books. Blatantly sexist and ethnically or racially offensive materials, on the other hand, were openly published: Pat and Mike, Hans and Fritz, Rastus and Mandy—glaring stereotypes that would astound the modern reader—appeared in magazines easily available at any magazine counter. Now that pattern is practically reversed: sexual materials are defended as an expression of free speech, but sexist, racist, and ethnically offensive slurs are considered nearly obscene.

Although they are now frowned upon, however, ethnic and similar jokes have not died out. They are widely told and even published, and evidently fill an important need. Most humor scholars agree that we laugh at those things that trouble us, frighten us, concern us most. If you assume that premise is generally true, social analysis becomes pretty easy. And a little unsettling. The explosion of "Polack" stories—brief, question-and-answer insults toward American Poles (and later, and even more uncomfortably, toward native Poles)—sprang from the growing insecurity of middle-class, white-collar workers in the Chicago-Gary area as blue-collar workers with names like Chelewski, Brynyzki, and Lukasiewz began to move up the economic ladder and occupy positions traditionally held by people with names like McGuire and Bauer. How can you tell which one is the bride at a Polack wedding? (She's the one with the clean bowling shirt.) Why doesn't a Polack make a good poker player? (Every time he gets a spade, he spits in his hands.) Get the point? The guy with the long name and no vowels can't even do labor right and now he wants to be a supervisor, the reasoning seems to go.

It's nothing new. The McGuires and Bauers had gone through the same sort of cultural hazing when the "Micks" and "Krauts" were clawing their way up that same slippery ladder earlier in the century, and in the previous century. I said above that these indicators can be unsettling. I don't have any trouble with such open labeling of those who are on the way up; what is unsettling is the unconscious soul-baring by those who tell the jokes, those who are threatened.

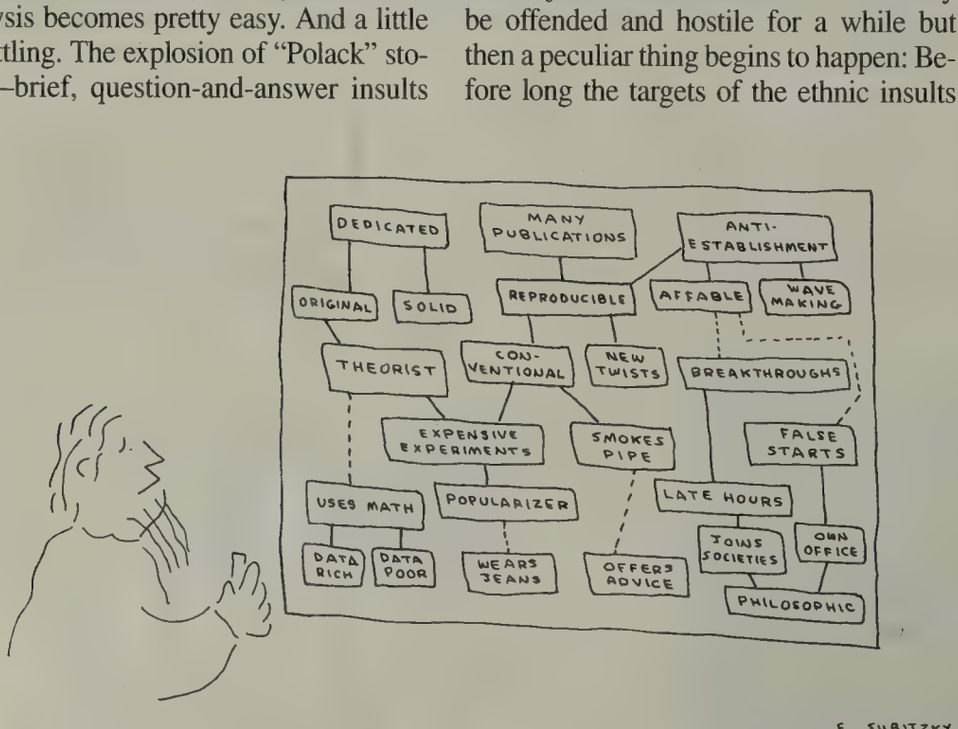
The safest butt of humor these days is ourselves, and that has opened a somewhat acceptable path to the ethnic joke. The objects of such insults and slurs may be offended and hostile for a while but then a peculiar thing begins to happen: Before long the targets of the ethnic insults begin to tell the jokes themselves! As white, I may be in trouble for suggesti there are peculiarities of black culture, b blacks can tell jokes about black culture

Linda, my Catholic, Bohemian wif can say that the only problem with being Bohemian Catholic is that as a Cathol she has only six "safe" days a month but a Bohemian she forgets which days th are; but this German Lutheran male is r stricted to reporting the line as hers. S blondes tell blonde jokes, homosexuals te homosexual jokes, and blonde, homose ual orphans tell blonde, homosexual o phan stories. Pretty soon what was once cruel insult becomes a banner of ethn pride. For good Ole and Lena stories, o goes to Norwegian communities in th Dakotas or Minnesota, where a promise "a new joke" is understood to mean a ne Ole and Lena story.

Metafolklore is folklore about folklor in this example, we have an Ole and Le story about Ole and Lena stories:

Ole likes to tell them Ole and Lena st ries but now and then he offends some his Norwegian countrymen. One day th Lutheran preacher takes Ole aside an tells him he should be a little more diplo matic about them stories and maybe eve do what the preacher himself does. Whe ever he wants to use a Norwegian story a Polack or Bohunk joke, he changes th name of the group over to some ancie biblical people like the Hittites, so's he ca avoid any problem of offending someon Ole thanks him for the advice an promises to use the idea the next time chance comes up, and sure enough, th night in the town tavern, the boys get t telling stories, and so when Ole's tur comes around he remembers what th preacher told him and he starts off, "Oka there was these two Hittites…named O and Lena, and they was going to Fargo or day…"

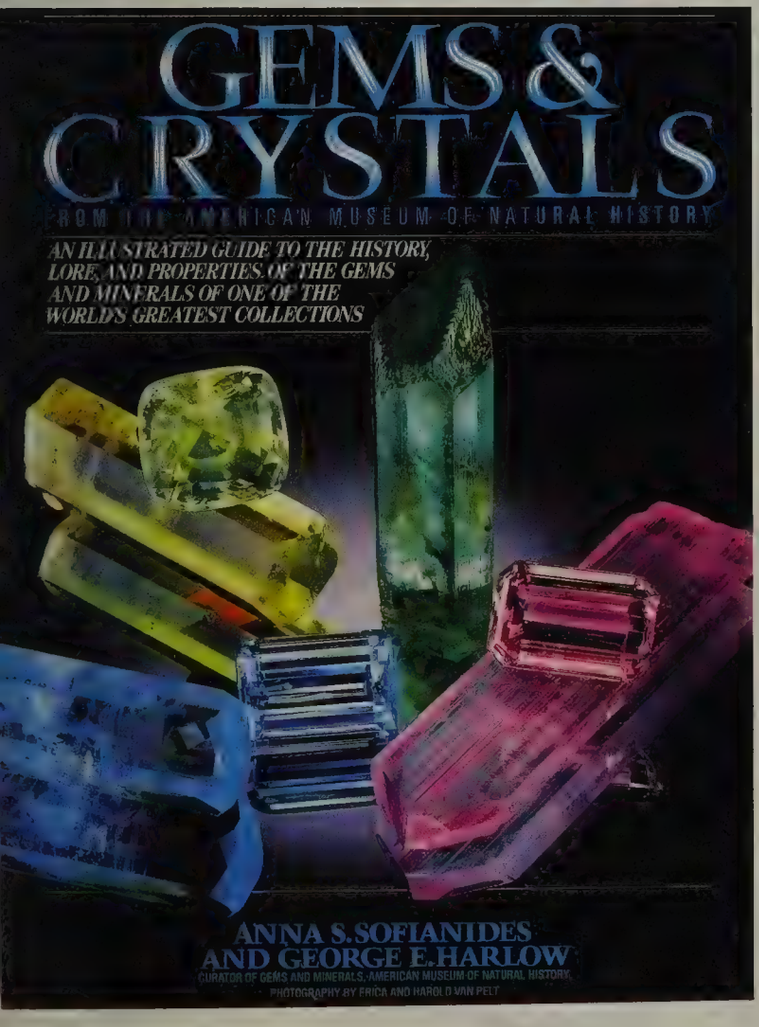
When I taught folklore at the Universit of Nebraska, I asked my students to kee journals in which they recorded whatev folklore that they saw around them on day-to-day basis. Throughout the sixtie and early seventies, men's journals wer full of pointedly sexist humor aimed at th feminist movement. In the early eightie women began to record in their journa jokes about the feminist movement. B the end of the eighties, the funniest, mo perceptive jokes about women and th feminist movement were written in jou nals submitted by women. The women movement (or at least a portion of it) wa approaching maturity.



E. SUBITZKY

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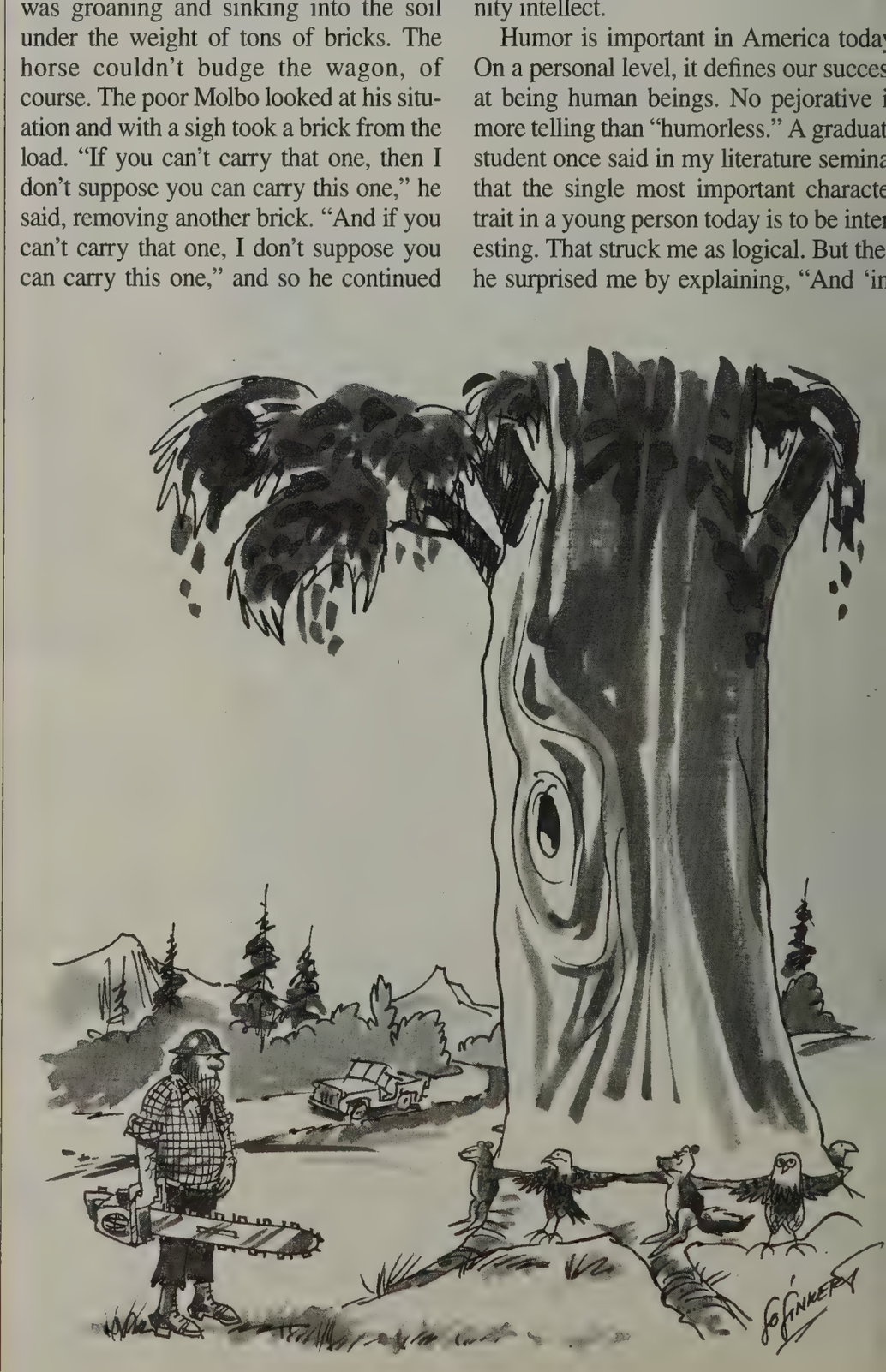
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This too is an old process. A very old form of European folk tale is the numskull story, a form of story that centers on the alleged stupidity of the citizens of some community or another—in England the numskull community is Gotham, in Germany it's Schildau, and in Denmark it's the peninsula of Mol:

A Molbo was about to load his wagon with bricks. He looked at the first brick, put it on his wagon, and said to his old horse, "Well, if you can carry that one, I guess you can carry this one." And he put another brick on the wagon. "And if you can carry that one, you can carry this one." Another brick. And so on, until the wagon was groaning and sinking into the soil under the weight of tons of bricks. The horse couldn't budge the wagon, of course. The poor Molbo looked at his situation and with a sigh took a brick from the load. "If you can't carry that one, then I don't suppose you can carry this one," he said, removing another brick. "And if you can't carry that one, I don't suppose you can carry this one," and so he continued on until the wagon was once again empty

Such stories, originally insults, hav been embraced by the community as a dis tinctive and favorable part of the village history and heritage. The traditional expla nation in most villages famous for the stupidity is that for centuries the popula tion was under constant attack and the ci izens carried off as prisoners because the were famous for their wisdom, and cap tives of Mol (or Schildau, or Gotham were prized by other, less-gifted nations a advisors and teachers. The folk theor continues that the alleged stupidity of th citizens is actually an artful sham, prac ticed to conceal an extraordinary commu nity intellect.

Humor is important in America today On a personal level, it defines our succes at being human beings. No pejorative i more telling than "humorless." A graduat student once said in my literature semina that the single most important characte trait in a young person today is to be inte esting. That struck me as logical. But the he surprised me by explaining, "And 'in



resting' means 'funny.' " Not bright, or ducated, or experienced, or wise, or romising, or ambitious, or serious, or edicated, or traveled, or thoughtful. unny.

But humor is gender-, culture-, and me-specific, a living, dynamic organism at changes every day in keeping with the hanges in its social context. Laughter is ot a universal language, and what one roup thinks is hilarious can be totally ob-cure to another. As a farmer living on the lains, I hear jokes and other forms of umor that I suspect are quite different out at least equivalent in terms of humor") from those heard by my col-agues in New York City.

"Last year was so tough, I planted 120 ushel of seed potatoes, worked the crop l summer, and in the fall harvested a rand total of exactly 120 bushel of pota-es. 'Course it was my own fault. I could ave planted more." My impression is that e story is funnier here on the rural coun-yside than it might be in the city. The dif-rence is not simply a matter of content; e biggest difference between rural and rban humor is style. The sledgehammer yle of Joan Rivers is urban humor—ard-edged, shocking, not always the sort f thing you want your children to hear. n the other hand, the humor I hear in the nall towns and on the farms of the Plains, ven the ribald humor, is so subtle, you ren't always sure when you've heard a oke. It is low-profile, ambiguous, and hen it is overheard by children, they ren't at all sure what it is they've heard:

The other day Jess Abernathy came into he tavern all sunshine and roses and Russ owers asked him what had made him so olly. He said that he had taken that old, o-good bull of his over to Lyle Rass-ussen at the vet clinic in St. Paul and yle gave him some new-fangled pills he nought might do the trick. But Lyle also arned Jess to be careful with the pills be-ause they were very powerful. Well, Jess aid he gave his bull just half of one of the ills and the bull perked up, took care of ess's herd, jumped the fence and took on an Leo's herd, and was last seen headed ast toward Bob Langford's dairy farm.

Russ Powers said, "Boy, that's some-ning, all right. What do you suppose is in nose pills that makes them so powerful?"

"I don't know," Jess said. "But they aste like peppermint."

As I said: subtle.

olklorist Roger L. Welsch lives on a tree arm in Dannebrog, Nebraska.



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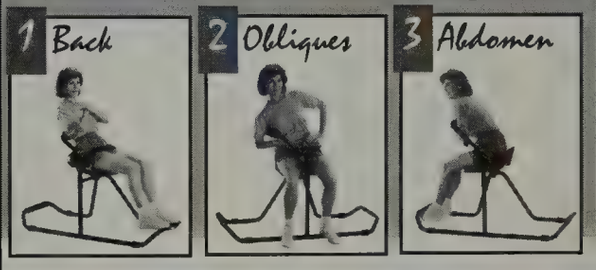
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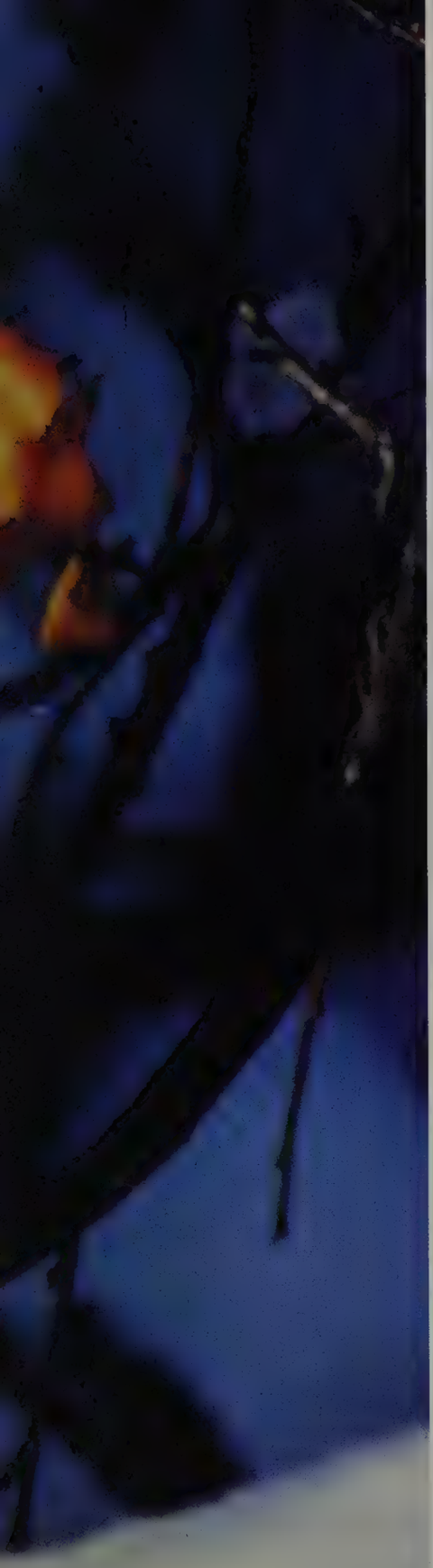
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A snowshoe hare's coat changes from summer brown to winter white.
Johnny Johnson

Hare-Raising Encounters

Unexpected dangers lurk in the Yukon for baby snowshoe hares

by Mark O'Donoghue and Susan Stuart

The week-old snowshoe hare huddled motionless under the low branches of a small spruce. All day, the baby hare, or leveret, had hidden in the same spot, its soft, mottled brown fur rendering it almost invisible—but not completely. Death came suddenly from the trees above. In an instant, a red squirrel—twice the size of the leveret—was upon it. Despite its shrill screams and attempts to flee, the young hare was soon overpowered. Responding to its cries, its mother rushed to the site, stomping her feet and clicking her teeth, but she arrived too late. The squirrel scampered up a nearby spruce tree with its prize and stashed the carcass in the crook of two branches for later consumption.

Squirrels killing hares? Squirrels have certainly been seen raiding bird nests, but we knew of no researchers who had noted squirrel predation on hares.

Our study of the ecology of juvenile snowshoe hares began in 1989, in Canada's Yukon Territory. Our work was part of the Kluane Boreal Forest Ecosystem Project, a cooperative research effort of three Canadian universities, whose aim is to examine the structure of the vertebrate community in the coniferous forests of the north. Our 125-square-mile study area was typical of boreal habitats found across a broad band of Canada, Alaska, and Eurasia. Spruce forest, broken occasionally by small natural clearings and aspen stands, dominated the landscape. A patchy and often dense understory of willows and bog birch provided ideal cover for the hares.

Throughout the northern part of their range in Canada and Alaska, snowshoe hare demographics undergo dramatic fluctuations at fairly regular intervals. These fluctuations are often referred to as the ten-year cycle because the hare populations reach very high densities (one to four hares per acre) every eight to eleven years, almost simultaneously across North America. Then, over the next few years, hare populations plummet. They fall as low as about one hare per 200 acres and stay at that level for several years, after which the cycle begins again.

This cycle is central to the functioning of the boreal community. As hare numbers rise and fall, so do the numbers of their predators, although predator numbers generally don't begin to decline until a year or so after the collapse of the hare population. Other boreal herbivore populations, such as grouse and squirrels, may also be affected by changes both in predator numbers and in the amount of food available after hare browsing.

Researchers vary in their explanations of why the hare cycle occurs—some support a predator–prey cycle, others cite a hare–vegetation interaction. All major studies, however, have noted the same demographic changes in hare populations over the course of the cycle. Whether in the Yukon, in Alberta, or in Minnesota, the survival rate of juveniles is the single most important factor responsible for increases or decreases in the hare population. However, the rate of juvenile survival measured in previous studies was always of hares older than one month. Younger hares were very difficult to find in the field and

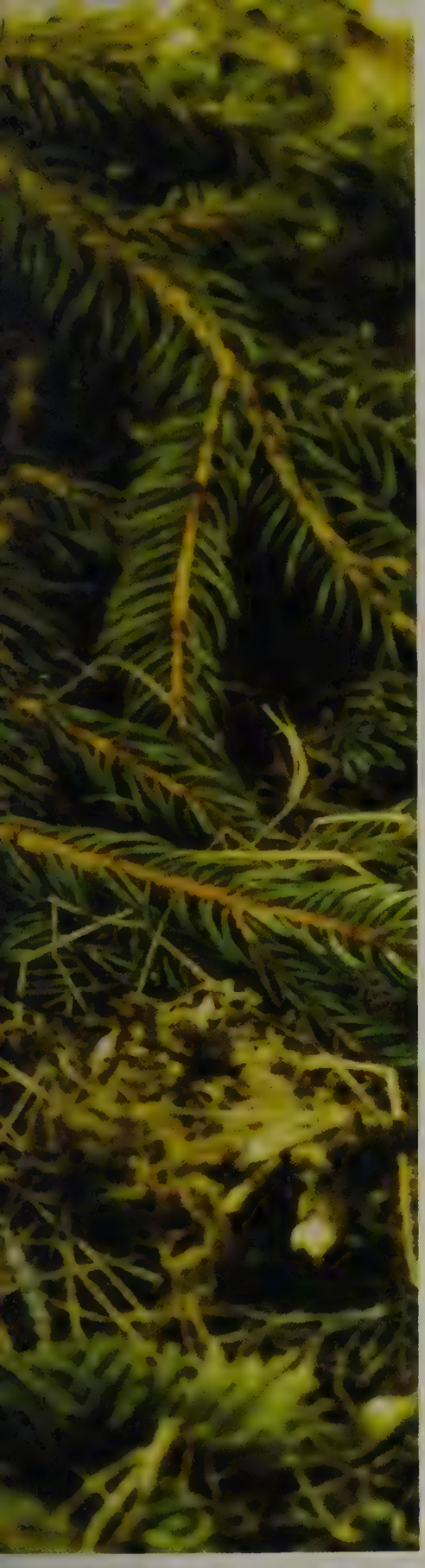


did not enter the live-traps set by biologists. The purpose of our research was to determine the survival rates of hares from birth through their first days and weeks and to investigate their ecology.

When we started our research, our challenge was to locate some leverets. Young hares are well camouflaged, and, unlike rabbits, which give birth in relatively conspicuous nests or burrows, hares are born in well-concealed depressions, often under logs or shrubs. To be certain of having animals to study, we placed pregnant female hares in individual pens a few days before they were ready to give birth. As soon as the hares were born, we removed the pens so that the mothers and young could move about freely. We ear-tagged 850 babies in order to identify them. And, to follow the young hares' movements more closely, we glued tiny radio transmitters, weighing approximately one-twentieth of an ounce, to the fur between th shoulder blades of 254 of the 850 hare We followed the leverets around ever day, noting as they grew how they fare during their first weeks of life.

Snowshoe hares are very prolific. Du ing the two summers of our study (whic took place during a period of high har numbers), most of the females produce three litters, each with one to nine young A female averaged about twelve youn

Mark O'Donoghue



Newborn hares huddle together beneath a white spruce, left. For the first few weeks of life, baby hares lie low, below, relying on the camouflage of their mottled brown fur and on well-concealed hiding spots for protection.

Stephen J. Krasemann; DRK Photo



ber season. Females usually mated again on the same day on which they gave birth, so the litters were spaced apart only by the snowshoe hare's thirty-six-day gestation period.

We were able to watch the birth of one litter quite closely. Sitting up on her hind legs, the doe gave birth to six young, cleaned them, and fed them their first meal, all in about fifteen minutes. She then moved away and did not associate with her litter again during the rest of the time that they were together in the pen, about ninety minutes.

Unlike rabbits, hares are born well-developed. They weigh approximately two ounces, are fully furred, and open their eyes within an hour of birth. They also gain coordination quickly and are soon mobile enough to crawl into a huddle with their siblings. Even before they are a day old, they can hop fast enough to make capturing them quite a challenge.

Most litters stayed together at the birth site for three to seven days. The amount of maternal attention the young hares received during this period varied. Although seldom coming close to their litters, some mothers stayed within 50 to 100 feet of their young for the entire day and vigorously chased away red squirrels, ground squirrels, and birds that wandered too near. Other females stayed completely away from their litters during the daytime.

When the baby hares first ventured out from their birth sites, they generally moved ten to twenty feet away and hid under shrubs, leaves, and logs. Occasionally we found one or more hiding together, but most of the leverets remained alone in these concealed spots, even on the first day away from their siblings.

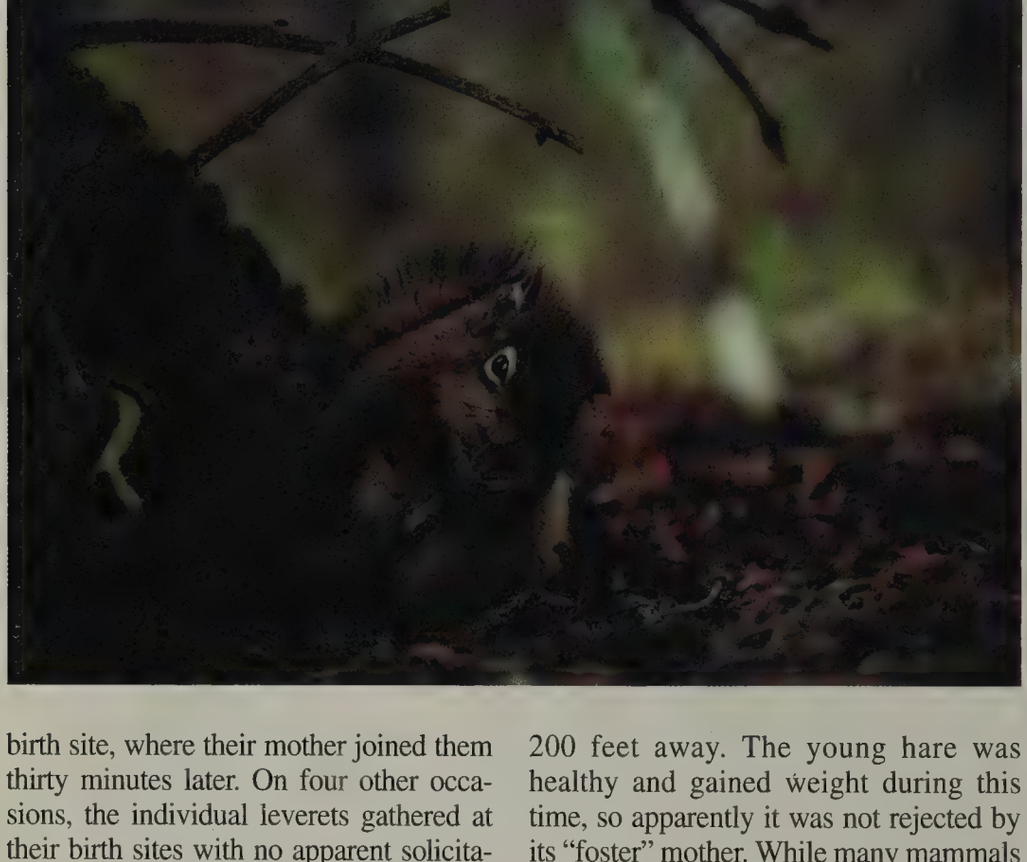
With the help of a colleague, Carita Bergman, we kept a round-the-clock watch at the birth sites of several mother hares to determine how and when their young were fed after their litters had broken up. From these observations, and from following the radio-tagged animals, we learned that in their first couple of weeks the leverets usually stayed hidden in their individual refuges during the day. Some leverets remained in the same hiding places, often more than 200 feet away from their birth sites and littermates, for more than a week. During their first few weeks, we observed juveniles nursing only once each day, shortly after twilight, which—in the long Yukon summer days—was usually between midnight and 1:00 A.M.

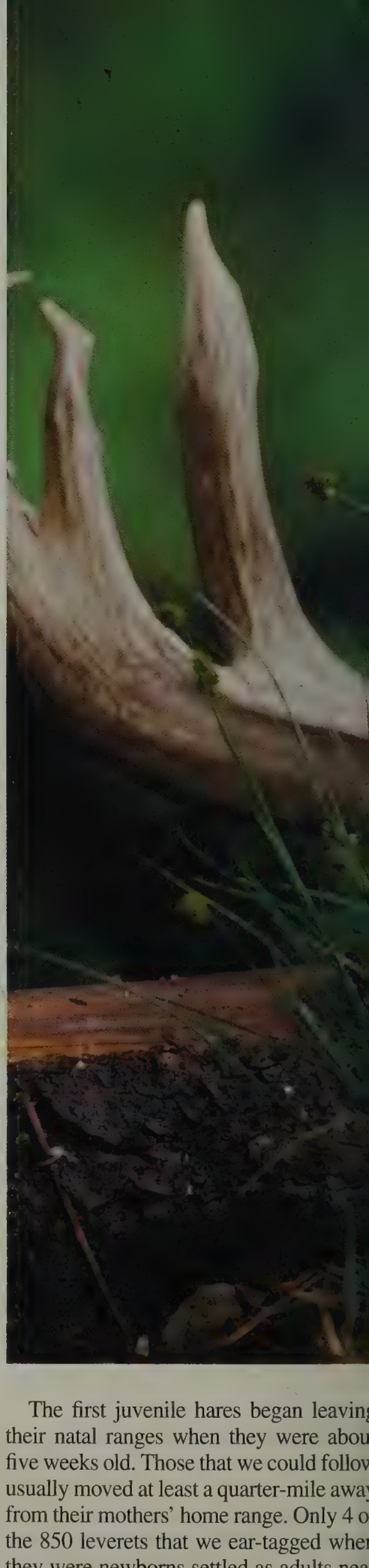
In two of the nursing sessions we observed, the mother hare hopped through the area in which her two young were hidden, about 120 feet from their birth site and 90 feet from each other, and made a high chirping noise. Then she appeared to leave the area. The leverets moved from their hiding places and regrouped at the

Erwin and Peggy Bauer

Red squirrels' appetite for more than seeds and cones is well documented. The squirrel below is chewing on the leg bone of an adult snowshoe hare, which it probably happened upon serendipitously. Deer antlers, right, can also offer a nutritious treat, providing calcium and other minerals.

Zena Tooze





birth site, where their mother joined them thirty minutes later. On four other occasions, the individual leverets gathered at their birth sites with no apparent solicitation from their mother. Each time, when the mother arrived at the birth site, she nursed her young for only about ten minutes before leaving again. By morning, each leveret was back in its individual hiding place. Orrin Rongstad and John Tester, both of the University of Minnesota, found a similar nursing pattern in 1966 when observing a single hare litter in Minnesota, as did French and Dutch researchers studying European hares. The European researchers also analyzed hare milk and found it to be extremely rich and concentrated, which is essential for animals that nurse their young so briefly and infrequently.

Once the leverets left their birth site, they seldom returned except to nurse. On one occasion, a litter of three seven-day-old leverets regrouped at their sheltered "nest" on a rainy day, four days after leaving it. On another, a radio-tagged leveret left its birth site at three days of age and was found during the next few days with the newborn litter of another female about 200 feet away. The young hare was healthy and gained weight during this time, so apparently it was not rejected by its "foster" mother. While many mammals will only care for their own offspring, leporids (hares and rabbits) may be an exception. Researchers studying European hares and swamp rabbits have also noted cases of females accepting strange young.

As the young hares grew older, they gradually ranged farther from their birth sites. By the age of twenty days, their home ranges approached those of their mothers in size (four to six acres). They also began to move more during the daytime. Hares younger than two weeks old could easily be approached while they remained motionless in their hiding places, but older leverets fled as soon as we got within ten to twenty feet of them. Judging from their droppings, the leverets had begun to feed on grass and other herbaceous plants when ten to fourteen days old, but they continued nursing for another week or two. After this age, most leverets were weaned, and their mothers had another litter on the way. Juveniles from the last litter of the season sometimes nursed until they were forty days old, however.

The first juvenile hares began leavin their natal ranges when they were abou five weeks old. Those that we could follo usually moved at least a quarter-mile awa from their mothers' home range. Only 4 o the 850 leverets that we ear-tagged whe they were newborns settled as adults nea their birth sites.

Soon after we started following th radio-tagged juveniles, we began to ge



ome puzzling results. Many of the lev-rets we tagged were killed before they vere ten days old, and we found almost alf of the carcasses (80 of the 170 that lied) in trees or in red squirrel middens. Another tenth (18) of the leveret carcasses nded up, mostly eaten, in arctic ground quirrel burrows.

Red squirrels were abundant on our tudy area. They constructed large under-ground middens around the bases of spruce trees where they stored their winter supply of spruce cones. The trees standing in the middens also typically served as sites for the squirrels' nests (irregular spheres of grass in the lower branches) and additional storage of mushrooms and other items they gathered. Ground squirrels were also common, especially in small clearings, and their extensive burrow systems dotted the floor of the forest.

At first, we concluded that these baby hares must have died of other causes and had then been scavenged by squirrels. We knew that both red and ground squirrels sometimes fed on carrion to supplement their mostly vegetarian diet. As our research progressed, however, we began to suspect that at least some of the carcasses must represent predation by the squirrels

Martin W. Grosnick

A summer of dining on a variety of herbaceous plants leaves a snowshoe hare, below, looking plump and well fed. In the winter, the hares turn to woody plants, such as willow, birch, and white spruce, right, for food.

Stephen J. Krasemann, Photo Researchers, Inc.



themselves. For one thing, the numbers of stashed hares just kept mounting, beyond what seemed reasonable if the squirrels were simply scavenging. For another, we couldn't think what predator *would* kill so many of the baby hares and then leave them around. Coyotes and lynx generally leave little behind when feeding on such small prey. Two other potential mammalian predators—weasels and martens—were scarce on our study site. And birds of prey, such as hawks and owls, typically either eat their prey at the spot where they made the kill or carry it off to their nests or special feeding trees.

Several observations bolstered our suspicions. During the course of our study, other biologists working in the area twice observed ground squirrels attacking and killing young hares. We also saw one red squirrel carrying a live, wounded leveret, and three others running away from freshly killed leverets. Just to be sure, however, we tested the scavenging efficiency of squirrels by placing carcasses of predator-killed leverets on our study sites. The squirrels only scavenged about one-quarter of them at the same time (early June) that we were finding evidence of squirrel predation for more than 85 percent of the juvenile mortalities. These findings, coupled with our observations of mother hares chasing squirrels from their litters, gave us strong evidence that both red squirrels and ground squirrels were indeed predators of snowshoe hares.

Over the course of the two summers of our study, we calculated that only about one-third of the baby hares survived th first two weeks of life. In the end, we con cluded that of those that died, about three quarters were killed by small mammalia predators, most likely red and groun squirrels. By contrast, only 5 percent o the radio-tagged leverets were killed b great-horned owls, northern goshawks and red-tailed hawks—animals generall thought of as significant predators of smal mammals. We have evidence from othe



esearch being conducted in the area that very young hares sometimes wind up being gulped down by coyotes and lynx and eaten by northern harriers and northern hawk owls. Even gray jays—robin-sized birds known as scavengers—have been seen killing baby hares.

By the time they are two weeks old, the leverets are too big and too fast for the smaller, opportunistic predators to catch. Until then, however, the best bet for a litter of young hares seems to be to lie low and to split up as soon as possible, so that if a predator does strike, it won't be able to feast on an entire litter. Similarly, the less often they nurse, the less likely they are to be discovered.

The behavior of young hares and their mothers makes a great deal of sense when considered as a defense against predators. The answers we have found, however, have left us with many new questions. Do squirrels prey extensively on leverets only when they are abundant? Does this predation have a significant effect on the hare cycle, or would most of the leverets have been killed later by other predators anyway? To answer these and other questions, we will need to return to the boreal woods at different points in the hare cycle and see how the leverets fare then. But we are sure that for baby snowshoe hares, the forest will always be full of danger. □

Victorian England's Hippomani

From the Nile to the Thames, they loved Obaysch

by Nina J. Root



Even before he was purchased by the American showman P. T. Barnum in 1892, Jumbo the elephant was a world-famous attraction at the London Zoo (see "A Big Pain," *Natural History,* March 1991). His name became part of our language, all but replacing "mammoth" as a synonym for immense, thus contributing to the durable oxymoron "jumbo shrimp."

Victorian zoogoers had another favorite, however, whose star rose in the firmament of animal celebrities and then disappeared. He was a hippopotamus named Obaysch, the first hippo seen in Europe since the time of Roman circuses. Captured in 1849, Obaysch arrived at precisely the right moment to seize the attention of London's burgeoning middle class, for exotic animals were becoming a national obsession.

Natural history was a popular craze. As the study of God's creations, it was considered morally uplifting and compatible with Victorian notions of respectability. Young and old, especially "ladies," collected shells and butterflies, pressed flowers, and raised hothouse orchids. Nature study was even healthful, prompting walks along the seashore or bird-watching tours through fields and woods. Victorian parlors displayed aquariums, fern collections, butterfly cases, albums of seaweed, and popular books on natural history. Zoological and botanical parks flourished as thousands flocked to marvel at rare and unfamiliar species brought from the corners of the Empire. Thus, the stage was set for the adulation of Obaysch, an enthusiasm that amounted to hippomania.

He was named for his native island of Obaysch in the White Nile, located south of Khartoum in the present Sudan. A few days after his birth, in the summer of 1849, hunters employed by the Viceroy of Egypt, Abbas Pasha, shot a female hippopotamus and discovered her infant hiding among the reeds. When they tried to grab him, the slippery calf plunged into the river and almost got away. One man struck him with a boat hook, leaving a scar Obaysch carried for the rest of his life, and then lifted the dazed animal into the boat. Obaysch continued to struggle, almost

Inspired by Obaysch, Joseph Wolf painted a herd of hippopotamuses on the Nile River for an 1861 portfolio of London's zoo animals.
AMNH Library





Obaysch's statue, top, made of hardened Nile mud, and sheet music for the "Hippopotamus Polka," left, survive from Victorian popular culture.
Zoological Society of London Library

Constant companions: keeper Hamet Safi Cannana and his celebrated charge, Obaysch, journeyed together to London from Cairo in 1850.
AMNH Library



apsizing the craft, but soon became exausted.

The hippo's extravagant transportation o Cairo, courtesy of the Abbas Pasha, was notable event. A special boat was built to arry Obaysch along the Nile, escorted by en Nubian soldiers and their lieutenant. His Highness the Abbas Pasha presented he animal to the British consul general, Mr. C. A. Murray, as a gift to the Zoological Society of London, and was in turn given several teams of fine greyhounds. With diplomatic pomp, the chief officer of he Pasha's palace accompanied the hippo o his temporary home at Cairo's British onsulate. On November 14, 1849, Mr. Murray wrote to the Zoological Society of London to announce the new acquisition, which "is now in a yard at the back of my house, and apparently in perfect health." Right from the start, Obaysch was treated with the care befitting a future celebrity. Wrote Murray, "It is only five or six months old, and still lives entirely on milk; think a fresh importation of cows will be necessary in Cairo, as our little monster akes about thirty quarts of milk daily for his share already."

Delighted by the enthusiastic reception of his gift, the Abbas Pasha ordered another of his officers, with a party of soldiers, to secure a young female from the White Nile, so that he might ship a pair back to England. The first expedition, however, was not successful in finding a suitable mate for Obaysch. Meanwhile, Murray continued to report on the hippo's progress:

> The Hippopotamus is quite well, and the delight of every one who sees him. He is as tame and playful as a Newfoundland puppy; knows his keepers, and follows them all over the courtyard; in short, if he continues gentle and intelligent as he promises to be, he will be the most attractive object ever seen in our Garden, and may be taught all the tricks usually performed by the elephant.

Obaysch lived with the Murrays for several months while suitable accommodations were built on a Pacific & Orient steamer. A keeper, Hamet Safi Cannana, had been hired to stay with him night and day. Hamet ended up sleeping on the floor beside his charge, because at night Obaysch would playfully tip him out of his hammock.

In the spring of 1850, Hamet and his assistants, two professional snake charmers, lured Obaysch into a padded cart and took him to Alexandria, where they boarded the pilot steamer *Ripon.* On the ship's main deck, a hippo house had been constructed, with steps leading into a tank that held 400 gallons of water. After a smooth crossing to Southampton, they traveled to London in a special train. Crowds gathered at every station, hoping to get a glimpse of the hippopotamus, but all they saw was Hamet, who popped out occasionally for air. On May 25, Obaysch and his keeper arrived in London, and were taken to the zoological gardens in Regents Park, where newly prepared quarters were to be the hippo's permanent home.

Zoo officials had no previous experience with hippos, but Obaysch's human companion had the situation well in hand. The zoologist Sir Richard Owen reported that

> the strong attachment of the animal to its keeper removed every difficulty in its various transfers from ship to train, and from wagon to its actual abode. On arriving at the Gardens, the Arab walked first out of the transport van, with a bag of dates over his shoulder, and the beast trotted after him, now and then lifting up its huge grotesque muzzle and sniffing at its favourite dainties,

Extraction of a fractured tooth by top-hatted zoo superintendent Abraham Bartlett, as sketched by a nineteenth-century London artist for Punch.
AMNH Library





Lewis Carroll's nonsense rhyme about a hippo riding a London bus became part of his comic epic "Bruno and Sylvie."
AMNH Library

with which it was duly rewarded on entering its apartment.

Soon Obaysch was well settled in. He had a pool, a sleeping room covered with straw, and a stuffed sack pillow, "of which the animal duly avails itself when it sleeps." Happy and contented only so long as his keeper was nearby, Obaysch grew "very impatient of any absence of its favourite attendant," during which he would rise on his hind legs and lean heavily on the wooden fence. He ate a porridge made with large quantities of milk and maize meal mixed together. Lewis Carroll even wrote a poem about the hippo's prodigious appetite:

> He thought he saw a Banker's Clerk
> Descending from the bus:
> He looked again, and found it was
> A Hippopotamus:
> "If this should stay to dine," he said,
> "There won't be much for us!"

Several thousand people lined up each Saturday to see Obaysch. Queen Victoria brought her children to his paddock and even recorded observations on the hippo's behavior and personality in her diary. Silver models of Obaysch were sold in the Strand, and the "Hippopotamus Polka" became an instant hit. The popular press, especially the British humor magazine *Punch,* chronicled practically every aspect of H. R. H.'s (His Rolling Hulk's) life, including the extraction of a broken tooth, his feud with the elephant keeper, and the time he and his new keeper unintentionally went swimming together.

After only a few years of hippomania, however, the public began to search for newer sensations. Even Charles Dickens decided that Obaysch was receiving too much attention and wrote an article in *Household Words* purporting to give equal time to the other zoo animals: the monkey screamed, at a specially convened court, that "favoritism is being shown the fat water-pig," and the hyena wanted to know what people found so endearing about a "swimming swine." In 1851, several successful rivals for the public's attention appeared: a newly arrived elephant and her calf and a great anteater from South America. According to *Punch,* Obaysch was petulant about these upstarts:

> I'm a hippish Hippopotamus
> and don't know what to do.
> For the public is inconstant
> and a fickle one, too.
> It smiled once upon me,
> and now I'm quite forgot;
> Neglected in my bath,
> and left to go to pot.

He regained some of his stardom, however, in 1854, when the Pasha's men finally succeeded in capturing a young female from his homeland, and sent her to London to be Obaysch's mate. She was called Adhela, or Dil, and the two hippos lived together for twenty-three years. After producing a stillborn infant, then one that died in infancy, Dil finally gave birth to a female that she successfully reared. Originally misnamed "Guy Fawkes," she was renamed "Miss Guy" when keepers realized their mistake. Obaysch's daughter lived to the age of thirty-six and left no offspring.

When he died on March 20, 1878, at the fairly early age of 29, *Punch* noted Obaysch's passing with a long hipposoliloquy, which included the lines:

> URM'P! Urm'p! A feeble grunt! I fail
> apace.
> Old Hippo's mighty yet melodious
> bass
> Sinks to a raucous whisper, short, not
> sweet!...
> I dreamt of [the White Nile] last night
> the unctuous ooze,
> Where one might take one's ease, and
> bask and snooze...
> Ah, well! I've had my triumphs, and
> am yet
> A Public Pet!

With the exception of Jumbo, no other captive animal's life had been so thoroughly recorded and popularized as Obaysch's, although he is all but forgotten today. Biographical material on the hippopotamus that captivated Victorian England now rests in the library of the Zoological Society of London. Visitors entering that library are greeted by a statue of Obaysch made of baked Nile mud. □

A mid-Victorian illustration, right, depicting a male hippo with his mate and calf was probably based on Obaysch's famous zoo family.
AMNH Library



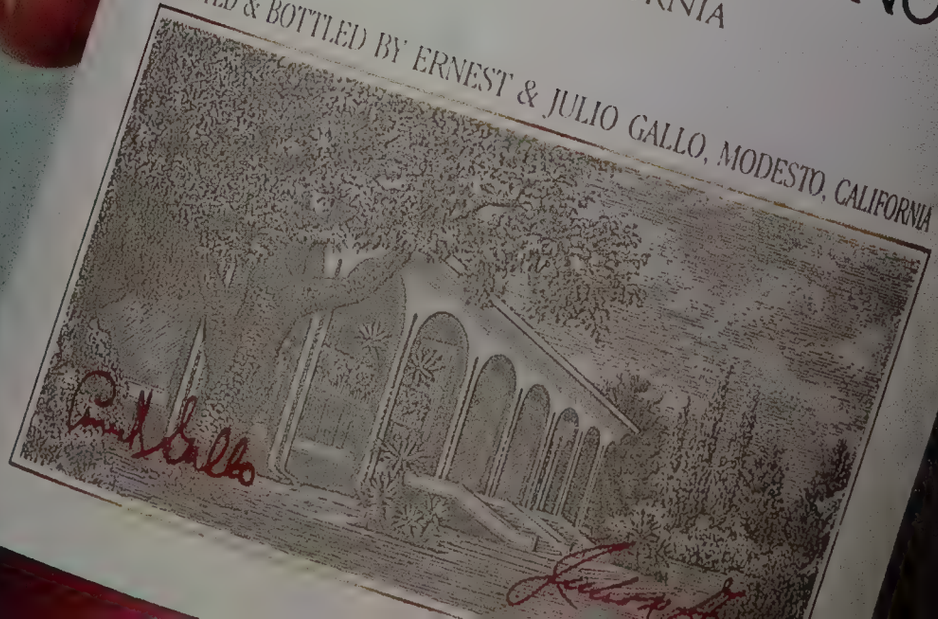
It's time for a change to the wines of Ernest and Julio Gallo



NORTHERN SONOMA
1986
VINTAGE

THE WINE CELLARS OF
Ernest & Julio Gallo
Northern Sonoma
CABERNET SAUVIGNON
OF CALIFORNIA

VINTED & BOTTLED BY ERNEST & JULIO GALLO, MODESTO, CALIFORNIA



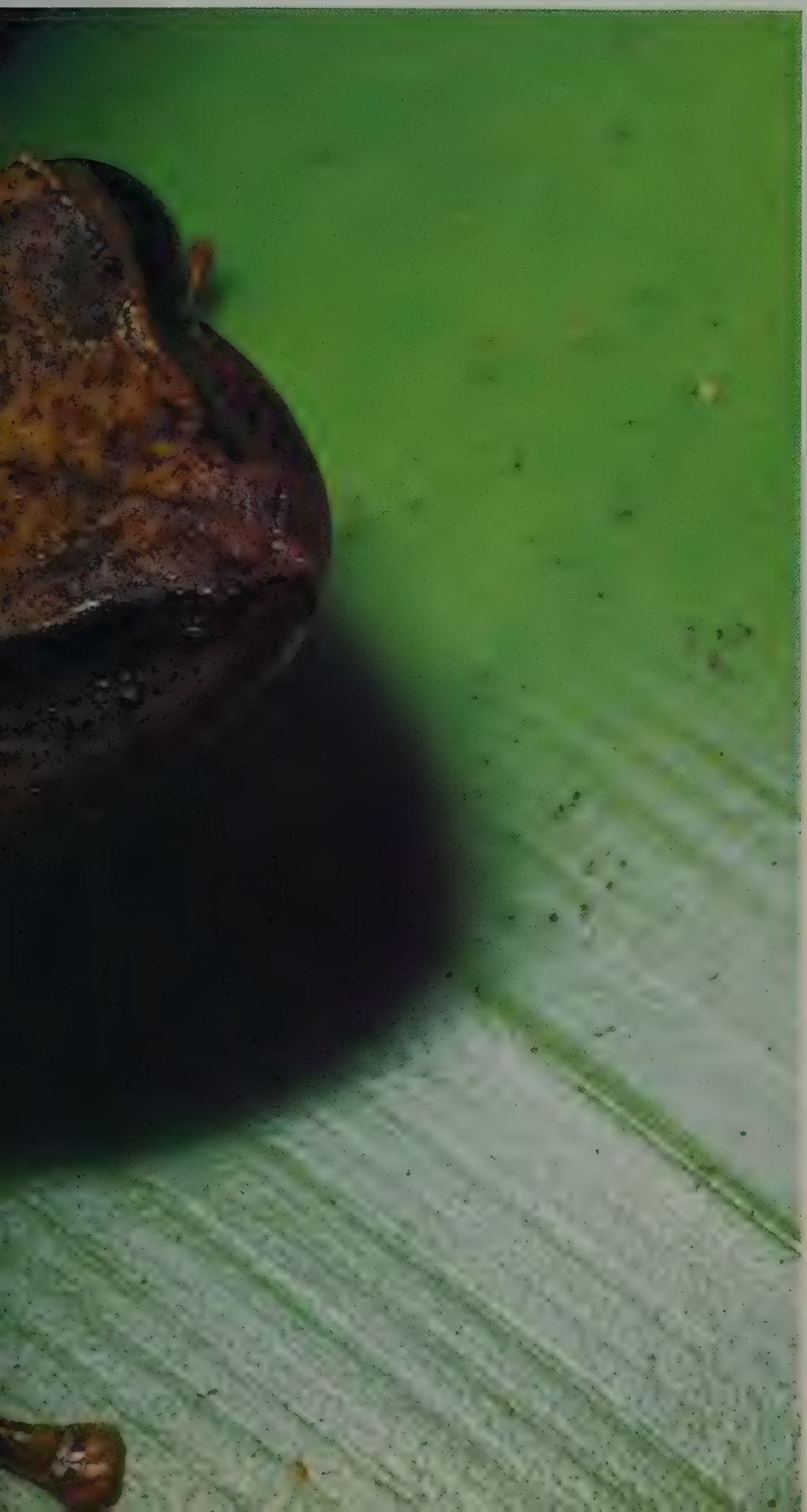
A coquí, native to Puerto Rico, clings to a bromeliad leaf.
Thomas R. Fletcher



Frequent Fliers

Each dawn, thousands of Puerto Rican rain forest frogs dive out of the treetops

by Margaret M. Stewart



A predawn downpour threatened at four o'clock in the morning, but still I sat on a boulder in the Puerto Rican rain forest waiting for something I had never seen: a shower of frogs. If frogs did indeed "rain" down, their behavior would explain several of my prior observations of the small frog called the coquí. I had been studying coquíes for five years and knew their habitat well, even at night. I felt comfortable in the midlevel rain forest on the slopes of the Luquillo Mountains (see "This Land," *Natural History,* October 1991), where tabonuco, guarea, *Cecropia,* and *Sloanea* trees formed a sixty-foot canopy over my head, and sierra palm fronds waved quietly in the balmy air. This area, near El Verde Field Station in the Caribbean National Forest, had become almost a second home for me. Every summer and between semesters I studied the frogs there.

In 1979, two Cornell graduate students, Carol Beuchat and John Thorbjarnarson, told me about an unexpected experience they had had at dawn after attempting to watch coquíes throughout the night. "Meg, we saw an amazing thing that you've got to see! At dawn the trees literally rained frogs! Frogs were 'plopping' all around us. What is going on?" It was four years before I was able to follow up on their observations. But there I was on a warm June night waiting for the falling frogs. Sure enough, at about five A.M., something landed on the leaf litter near me. It sounded heavier than a falling leaf, but not so sharp as crackling twigs: a sort of dull "plop." I rushed to the spot and found a coquí, sitting on top of a leaf that was still swaying from the frog's impact. Then I heard something land on a palm frond near my head. Another coquí! I heard several more, but could not see them. Coquíes are so well camouflaged that sometimes I could stare directly at one on the brownish leaf litter and not see it until it moved. Over the next few weeks, I repeated my dawn vigil many times. Some days, showers made it too difficult to hear the frogs land. On other mornings, strong gusts of wind moved through the forest just when the frogs should have been

"plopping" and I could not hear them falling.

I had been studying population regulation and reproductive biology of several species in this region. The coquí is the largest (less than two inches long) and most numerous of some twelve species of *Eleutherodactylus* that live in Puerto Rico's montane rain forests. I was curious to know how this forest, which seemed relatively free of insects, could support frog populations as dense as 10,000 individuals per acre. To understand the frogs' population dynamics, I had set up experimental study plots by hanging many tree trunks with small bamboo "frog houses": six-inch sections of bamboo stem, covered on one end to prevent desiccation. Coquíes, like other frogs of the genus, do not breed in ponds. They lay eggs in rolled leaves, under bark, in tree holes, or in other damp, semienclosed spaces. Males brood the eggs, which hatch directly into tiny housefly-sized froglets. (see *Natural History,* May 1987). Nocturnal by habit, coquíes spend the day in their nest sites, emerging at dusk to call, forage, and court. At dawn they are back in their safe hiding places. I had suspected that available nest and retreat sites were a major factor limiting population density, and my first experiments abundantly confirmed that view. The frogs readily accepted the bamboo houses, which allowed me to elevate the populations in my experimental plots to as much as five times those in control plots lacking the artificial shelters.

Except for brooding fathers guarding their egg clutches against predation by other males and from desiccation, frogs left their houses on most nights before eight o'clock, and returned before seven o'clock in the morning. Males, who were calling for mates, preferred to sit on pepper bush leaves in the understory at night, but females and noncalling males disappeared and I did not know where they went. The obvious place was the canopy. Were the frogs climbing up into the trees to seek food or, perhaps, to avoid ground-dwelling predators and escape competition from other frogs?



Photographed repeatedly with a strobe light during free fall, coquí, left, adjusts its position in midflight. During its parachuting" drop, below, a coquí assumes a typical played-out posture, which slows descent.
oth studio photographs by C.E. Miller; MIT



Fortunately, there was a seventy-two-oot aluminum tower in the forest near the eld station. From the tower platforms, laced at six-foot intervals, we could peer nto the canopy at various levels and see rogs sitting on large limbs and leaves. We lso tied frog houses to the corners of ten latforms on the tower. From our observa-ons we learned that frogs used retreats nd nests at all levels except the treetops nat protruded above the canopy, which vere too dry for the frogs. Frog houses bove the canopy quickly dried out be-ause winds were much stronger there nan within the protective leaf cover. My Cornell University colleagues on coquí tudies, Harvey Pough and his students, ad learned that frogs may dry out during ne night in the canopy unless they are able o rehydrate. Frogs do not drink, but ab-orb water from a thin area of abdominal kin, called the pelvic patch. Normally, co-quíes can replace water during the day imply by staying in their moist retreats. I ave watched frogs, just after plopping down from the canopy, spread themselves against wet moss on tree roots to rehydrate. In time, I learned that most climbing occurred after at least three days of rain, when frogs are fully hydrated.

My assistant Ulmar Grafe enjoyed staying on the tower; he spent several nights there observing the coquíes as they returned to their bamboo houses. When it was raining, the frogs sometimes slid backward along the tower's slippery aluminum support rods, despite enlarged toe discs, and had to make several tries to reach home. Eventually, we observed frogs jumping as much as forty-five feet from their bamboo houses on the tower to the ground below.

Since we knew such falls wouldn't hurt the frogs, we decided to drop them from various heights to observe the behavior they use to control and break their falls. I "jumped" the frogs from different heights on the tower while observers on the ground timed their descent with watches. As each frog entered free fall, it extended its arms and legs, bent at the knee and elbow joints, and spread its fingers and toes. The frogs rotated slowly as they descended. Apparently, spreading the limbs stabilizes the body and keeps it from toppling over and over during the fall.

We observed the same behavior in a close relative of the coquí, *Eleutherodactylus portoricensis,* which also lives in the forest. Although these frogs are not true gliders, they can influence the direction of their fall, deflecting it by as much as three to six feet from the vertical. Coquíes fall at angles less than 45° from the vertical, a behavior known as parachuting. True gliding frogs descend at angles greater than 45° and can turn in "flight." Sharon Emerson's studies show that the Wallace's flying frog greatly influences the speed and direction of its fall. Unlike the coquíes, these Borneo frogs have webbed feet and skin flaps.

When we simultaneously dropped a live frog and a dead frog from heights of up to forty feet on the tower, the live frog

always fell more slowly than the dead frog. The posture and extended arms and legs make a difference in fall rate, even for a 2.5 to 3.6 gram frog. Because they are so light, coquíes land unharmed.

I reasoned that if most nonbrooding frogs go to the canopy to forage, we should be able to see many of them heading up tree trunks—yet we had rarely observed them climbing. I finally realized why. The frogs were going after their dinner at the same time we were cooking our evening meal of beans and rice in the tiny field station kitchen. I mobilized two of my assistants, Nancy Humphrey and John Lasher, and we marked fifty adjacent forest trees with numbered strips of yellow tape. During what had been our dinner hour, from dusk until after dark, using flashlights and moving quickly from one tree to the next, we counted all frogs climbing each trunk, then noted the tree's identification numbers. Sure enough, most frogs climbed between 7:00 and 7:30, with as many as eight frogs climbing one trunk. By 7:30, the forest was dark, and the coquí chorus became ear-splitting. After making many counts under different weather conditions and at different times of the year, we ascertained that regardless of season, more frogs climbed on warm, humid nights and after wet days than when the weather was cool, dry, or windy. One of my team was usually "plopped" on by a coquí during the night. I remember my alarm in the dark of night when a coquí landed on my head! Not all frogs waited for dawn to return from the canopy; drying winds brought some down earlier.

We were surprised to learn that most frogs climbed during a fifteen-minute period. Why such coordinated mass movements? An important reason may be to keep from becoming another creature's dinner. Several large invertebrate predators wait on the tree trunks for large insects and frogs. Among them are tarantulas that build lichen-covered "hides" on the tree trunk, emerging at night to ambush prey. Another is an arachnid relative of scorpions known as the *guavá*, whose elongated first pair of legs detect approaching prey.

Fish Gotta Swim, Frogs Gotta Fly

by Sharon B. Emerson

While a coquí has no special anatomy to assist its airborne locomotion, its cousin in Borneo—Wallace's flying frog—is well adapted for gliding through the air. First described by the British naturalist and evolutionist Alfred Russel Wallace in 1869, Wallace's flying frog seems designed for flight. Most arboreal frogs are slender, but the flying frog is downright skinny, built for lightness, with parts of its shoulder and pelvic girdles often visible through the skin. In addition, Wallace's flying frog has enlarged hands and feet, enormous toe pads, full webbing between fingers and toes, and lateral flaps of skin on its arms and legs. Close to four inches in body length (more than 60 percent of all frogs are under one inch), it is colored a bright chartreuse green, with brilliant yellow and black lines marking the webbing between toes and fingers—a spectacular sight as it sails through the air.

At home in the canopy of the Bornean rain forest, 50 to 150 feet high, the frog must descend close to the ground to breed. Smaller treefrogs can use water trapped in the axils of plants or treeholes as nurseries but these large frogs produce big tadpoles which need more room. At breeding time the adults glide down to vegetation that hangs just above small pools on the forest floor. There each pair produces a clutch of externally fertilized eggs, embedded in a foam nest, which they attach to a leaf. When tadpoles hatch, they wriggle free of the foam and drop into the pool, where they develop into frogs.

Of the 3,400 species of living frogs, fewer than a dozen are known to be "fliers," although none of them really flies. Rather they glide, holding their hands and feet fixed laterally to their bodies and descending at an angle of more than 45° from the vertical.

Mimi Koehl, of the University of California, Berkeley, and I have made and tested biomechanical models of various materials to learn how frogs' shapes affect their gliding ability. With all models, the speed of fall is related to their weight per unit of surface. To descend at a slower speed, they would need a lower weight



An illustration of Wallace's flying frog, from The Malay Archipelago, *by Alfred Russel Wallace (1869)*
Margaret M. Stewart

d/or increased surface area. Wallace's
ing frog has evolved both. It weighs less
n other frogs of the same body length
d, with webs extended, has a much
ater surface area. Models also had to
proximate the behavioral postures as-
ned by frogs in flight. The coquíes of
erto Rico, for instance, "parachute" out
trees while assuming the same splayed-
t pose as Wallace's frog, even though
y lack any special anatomy for gliding.
We built a series of frog models that we
ld test in a wind tunnel, just as airplane
nufacturers test various aerodynamic
signs. By adjusting limb positions and
anging the models' shapes, we could
asure the effects on flight efficiency.
st, we analyzed Wallace's flying frog by
ding each of its specialized features in-
pendently to a model and recording the
del's performance with each addition.
our surprise, when all the flying special-
tions were in place, the total effect was
ch greater than the sum of each fea-
e's individual contribution. The group
flying adaptations appears to have
olved as an integrated system, rather
n piecemeal.
When the typical flying posture was
upled with the true flying frog's shape,
ery aspect of aerial performance in-
ased. Such frog models traveled longer
rizontal distances and were more ma-
uverable in the air than those that had the
timal flying shape but were tested with
bs drawn close to the body. Either with
without the "flier's" shape, laterally ex-
ded hands and feet dramatically in-
ased stability. When the hind limbs
re placed parallel and behind the body
any frog model, it always landed upside
wn. In contrast, when the limbs were ex-
ded at right angles to the body, models
ways landed right side up. When frogs
ch as the coquí spread out their hands
d feet, lateral to the body, they gain sta-
ity during descent despite the lack of
y special modifications for gliding.
eir "skydiving" behavior suggests a
usible antecedent for how Bornean fly-
frogs may have evolved.

aron B. Emerson is a research professor the Department of Biology at the Uni-rsity of Utah. Her research has explored relationships between morphology, rformance, and ecology in vertebrate imals.

The misty rain forest canopy that surrounds the mountain El Yunque in Puerto Rico's Caribbean National Forest provides prime habitat for coquíes.
Mark Warner



The *guavá* grabs frogs with its spiny pincers, then defleshes the frogs with its mouthparts.

Fifteen of our fifty marked transect trees had a resident *guavá.* Somehow the frogs have "learned" to time their ascent precisely, for these predators emerge only after 7:30, just after the peak of the frogs' upward migration. Not all frogs made it, however, for occasionally we saw a *guavá* deflesh a coquí, and we also saw tarantulas catching coquíes.

Coquíes are also menaced by the diminutive Puerto Rican owl, a nocturnal bird in the forest. We don't know how or when the owl catches frogs, but its nests are littered with coquí carcasses. Frogs descend from the canopy just before their other enemies, the lizard cuckoo or the pearly-eyed thrasher, become active. At dusk, when the frogs emerge, these hunting birds are becoming inactive for the night. Even so, coquíes run a high risk from both invertebrate and vertebrate predators.

What triggers the coquíes to climb? Apparently light levels set the time, for the ascent varied with cloud cover or seasonally as day length changed (it varies by two hours during the year). By measuring illumination on the forest floor at both dawn and dusk, we learned that the frogs time their movements precisely with light levels.

The frogs' vocalizations provided another clue to their behavior. At dawn, the coquí chorus switches from advertisement calls (co-quí) to aggressive calls (co-quí-quí-quí, co-co-quí-quí), and the opposite switch occurs at dusk. Most aggressive calls are given at dawn just after frogs have plopped to the ground and returned to their retreats. In the evening, they give the same calls most frequently just before they leave their retreats for low calling sites or the canopy. Such sounds may even stimulate stragglers to call and to move at the appropriate time.

Why would the little frogs expend so much energy and risk death by climbing way up to the canopy every night? I suspected that there must be a greater abundance of food in the canopy, but observations of night feeding were almost impossible. How could we learn what the frogs were eating in the treetops? I decided to catch frogs after they dropped to the ground and check their stomach contents. Frogs, like fishes, lack strong sphincter muscles between the esophagus

Philip A. Savo

At El Verde Field Station, a coquí secures itself to a leaf, below, using suction pads on its feet. Wallace's flying frog, right, is noticeably skinny, an adaptation for gliding.
Anne Heimann



and the stomach. A little water squirted into their mouths will flush out their last meal—a convenient way to obtain data without killing the frog.

My efforts to catch enough canopy frogs at dawn failed, but in 1989 we were able to take advantage of a new set of canopy towers, from which assistant Mike Flynn captured several frogs just as they were about to drop from the high branches. Sure enough, they contained many more food items in their stomachs than did frogs taken near the ground, including several prey species not found in understory frogs. Canopy foraging provides a feast worth the effort and risk.

Another benefit of foraging in the canopy is that it allows the frogs to feed over a much wider area than does the understory. When we counted frogs climbing tree trunks, we found that on favorable nights as much as 70 percent of the population took to the canopy. Larger trees with fuller limbs had more frogs using their trunk "corridor." Since coquíes are very aggressive and intolerant of other individuals, the distance between calling males is never less than twenty inches, and horizontal home territories average ten feet across. In the canopy, the frogs are "layered" on the leaf surfaces, which gives them more than fifty feet of vertical range to occupy. Perhaps canopy foraging is the reason the forest can support such high densities of coquíes.

But why keep returning to the ground? Coquíes, unlike most other arboreal frogs, do not need to find ponds or even tiny pools between plant leaves for reproduction. They do need moisture, however, so most coquíes lay their eggs close to the ground where desiccation is less of a problem. Unless rains are frequent, the canopy becomes too hot and dry during the day.

Climbing trees at night and jumping ou at dawn are behaviors not limited to frogs Charles Elton, the great English ecologist described such behavior for many wing less insects in Wytham Woods near Ox ford. Because of the abundant traffic o tree trunks that link the ground to th canopy, Elton likened them to the Grea Trunk Road of India. Caterpillars of many nocturnal moths head down toward th ground by day and "gallop" back u trunks after dark to feed in the canopy dur ing the night. The abundance of insec food in the canopy can provide fine forag ing for arboreal frogs. Since most birds important predators on both insects an frogs, are diurnal, foraging at night can b much safer. Climatic conditions at nigh are also better for small creatures that ar susceptible to drying or overheating.

For small animals, parachuting an gliding are safe and energetically inexpen sive ways of getting to the ground an avoiding predators. Most probably de scend in steps rather than leaping the en tire distance to the ground in one jump, al though they are capable of doing that Palm fronds provide broad surfaces fo landing pads. I even learned to recognize the sound of a frog landing on a palm frond. True gliding frogs, with webbed feet, occur in several different families o frogs and are found in arboreal habitats o every continent except Antarctica. Para chuting frogs, such as the coquí, are not so easily recognized by their shape, but they may be much more common among arbo real frogs than anyone expected. Just this summer in upstate New York, I watched the common gray treefrog jump from the trees to the ground at the pond edge a dusk. It was moving from the canopy where it spends the day, to the water to breed. The coquí, by contrast, goes from the understory, where it spends the day, to the canopy at night to forage. But it was the high density of the coquíes that made their parachuting behavior obvious to Carol and John, who just happened to be in the forest at dawn when the litter was dry enough so that they could hear the frogs raining down. □





short-tailed weasel, or ermine, searches for prey eneath the snow's surface.
ight Kuhn

The Underside of Winter

Vhen spring comes, the hidden world beneath the snow may wake up first

y Peter J. Marchand

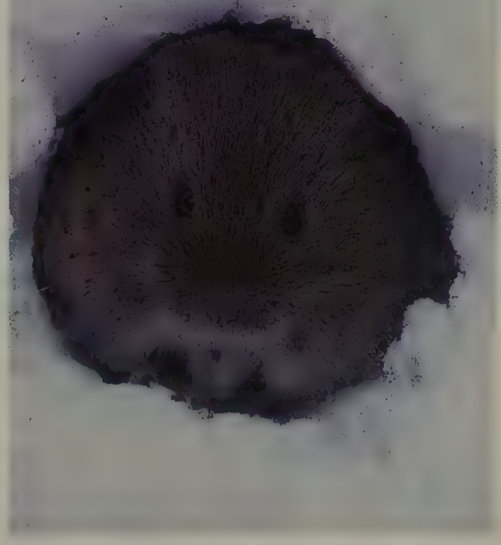
It was a moody fall day in the Colorado ockies when Joseph Merritt hitched up s heavy pack, gathered as much research quipment in his arms as he could man-ge, and started the arduous climb toward iwot Ridge. He was headed for the high ruce-fir forest 11,000 feet up the moun-inside, where he planned to set out a grid live-traps to study the population dy-amics of the red-backed vole. For a mam-alogist, his purpose was hardly unusual. e would be capturing and examining the ecretive animals, then marking and re-asing them to monitor individual devel-pment and population changes over time. Vhat made his task more difficult than sual, however, was that this investigation ould take him all through the long winter nd into the following spring—a time hen most biologists were in heated ooms, comfortably working over data om their summer field season. To ob-erve his animals through the winter, Mer-tt had to haul all the paraphernalia neces-ary to construct chimneys around his aps so that after the snows covered the round with a deep blanket, he would still ave undisturbed access to the forest floor.

By late spring, Merritt had acquired ore the demeanor of a Canadian fur trap-er than that of the doctoral candidate he as, although certain aspects of his rou-ne would surely have perplexed and robably amused the former. Eight days a onth, from December to June, Merritt la-oriously broke fresh trail on snowshoes reach his trapline. He located the traps, ne at a time, by markers placed overhead the trees. At each trapsite, he would rop his pack in the snow, open his heavy cket, and start shoveling. About three eet down into the snowpack, Merritt ould slow down a bit and scrape around gingerly until he found the top of the trap chimney. No matter how hard the work, or how many times he had done it, his anticipation at the first sight of the trap invariably recharged him.

One bright spring day in early June, Merritt was rewarded for his effort with a dividend. He carefully brushed the snow from the chimney of trap C12 and lifted the cover. With a pair of long wooden tongs, he reached another three feet down and gently clasped the small aluminum box at the bottom of the shaft. Once he had retrieved the box and brought it into the glistening light above the snowpack, he coaxed a small russet animal with jet black eyes, and barely any ears, from the warmth of the trap and examined it carefully. He was not expecting what he found in his trap this time: the vole was a juvenile, perhaps only two weeks old, born under the depths of snow two months before it would first feel the warmth of sunlight on the forest floor. Merritt examined it again, recorded its weight, and with a twinge of excitement, returned the young animal, christened CG-HR3, back to the dark abyss under the snowpack.

Three hundred miles to the west, in Utah's Wasatch National Forest, Frank Salisbury nudged his cumbersome snowcat into a small, deeply drifted clearing among the aspens of Franklin Basin. With a sigh of relief, he cut the engine and sat for a few minutes listening to the stillness. Everything around him appeared pristine and natural, but for one thing: next to his machine, protruding from the snowpack, was a large, corrugated steel silo, complete with ladder and a covered hatchway on top. After a thoughtful moment, Salisbury pulled himself up and stood on the cleated track of the snowcat. He reached for a rung of the ladder and in a few steps disappeared down into the silo.

Salisbury was on an odd mission for NASA. A plant physiologist from Utah State University, he had been awarded a grant from the space agency to study plant growth under extreme environments, and he was on his way now to his laboratory—not in outer space, but instead in the inner twilight of the world beneath the deep Utah snowpack. Salisbury had built a growth chamber below ground, equipped with numerous roof-level ports and alcoves, whereby he could monitor the subtlest responses of plant cells to the environment of this cold, snowy underworld. As his eyes adjusted to the darkness, he moved across the small room to the far corner and carefully detached a metal plate from near the ceiling, opening an unobstructed window into the dim world

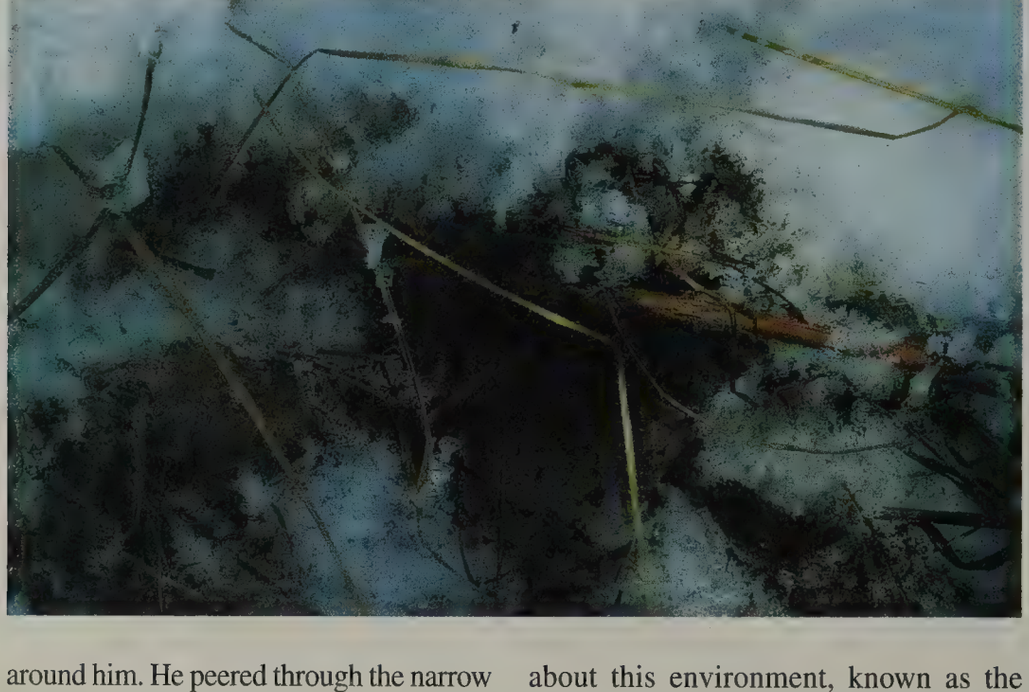


Voles often dig openings in the snow surface, perhaps to release built-up carbon dioxide, or perhaps to see if spring is on its way.
Rod Planck

Many small mammals, such as the red-backed voles at right, take advantage of this subnivean world.
Sandra Miller



Over time, ice grains at the base of the snowpack change their shape and size and become brittle. Eventually they dissipate, creating open spaces under the snow, below.
Peter J. Marchand



around him. He peered through the narrow slit of emptiness under the delicate roof of the snowpack at a tray of germinating seeds. Satisfied with what he saw, he backed away carefully and prepared to measure with sophisticated instruments what the human eye could detect but not quantify—the penetration of solar energy to his responding plants through nearly six feet of snow.

These observations of plant and animal activity under snow were not the first on record. Some of the earliest impressions of life in this environment come from the pioneering efforts of the Soviet ecologist A. N. Formozov, who nearly fifty years ago espoused the importance of snow cover to the successful overwintering of small mammals in the north. The studies by Merritt and Salisbury, however, suggested that plants and animals were not merely surviving the rigors of winter under the sheltering snow cover, but were growing, prospering, and even reproducing. Their research raised several new questions about the true nature of this unseen world. If plants and animals under six feet of snow were behaving as if it were spring, what signals were they receiving from the "outside"? And what changes were occurring within their realm? These are among the questions my students and I have been asking over the past decade about this environment, known as the "subnivean," in which plants and animals may carry on life for up to seven months of the year.

In the broadest sense of the word, subnivean refers to any space beneath the upper surface of the snowpack that may be occupied by plants or animals. Thus, a deer mouse that tunnels into the snowpack from the surface to form what I call a "resting cavity" is temporarily exploiting one dimension of the subnivean environment. However, in a more specific sense, the term subnivean refers to the negotiable, although often discontinuous, space at the base of the snowpack, where the snow meets the ground.

Much of the free space beneath the snowpack owes its origin to the metamorphosis of snow crystals as they undergo transformation of shape and size. Almost from the moment a snowflake comes to rest, molecules on the surface of the ice begin migrating from sharp points to concavities in the crystal to form more or less rounded ice grains. These grains of ice pack more closely together, resulting in a rapid increase in the density and bonding of the snow. In time, however, the ice grains at the base of the snowpack begin to disintegrate, forming brittle, loosely aggregated crystals, known as "depth hoar," which break up easily and eventually dissipate. These changes occur in response t temperature and vapor-concentration gra dients within the snowpack, with wate vapor migrating from the lower, warme layers to the colder strata above, where condenses. Ice grains in the upper portio of the snowpack thus grow by accretion, a the expense of those dissipating near th base. The process continues as long as temperature gradient exists, so that ove time numerous voids develop within th litter layer under the snowpack. This is th subnivean space, where so much life goe on unseen, that I have sought to character ize in terms of its thermal stability, ligh regime, and air quality.

The steep temperature gradients ofte observed within the snowpack are testi mony to the excellent insulative qualitie of snow. I have recorded subnivean tem peratures of 32° F beneath just sixtee inches of snow when the air above was frigid –31° F. This capacity to buffer win ter's snapping cold is the primary advan



ıge of snow cover to subnivean plants and nimals. However, not all snow cover is reated equally. Seemingly small differnces in snowpack density can make a sigificant difference in its thermal conducvity. From the onset of my studies I eeded a simple way to evaluate the insuative quality of a snow cover to determine ow much snow under a given set of cirumstances is enough to provide the therıal protection that plants and animals eed.

Over the course of several winters at the Center for Northern Studies in northern Vermont, my students and I implanted numerous probes within the snow and subivean space to monitor temperature fluctuations as snow cover changed over time. We devised a simple index, dividing snow epth by density, to characterize the therıal quality of the snowpack. When we lotted our index against the ratio of airemperature fluctuations above and beeath the snow, we found a magic number. Any combination of depth-divided-by-density that yielded an index value of 200 conferred maximum thermal protection; further additions of snow made little difference. This meant, for example, that 8 inches of snow of 0.1 g/cm^3 (equivalent to a very fresh snowfall) was enough to completely buffer short-term temperature fluctuations in the subnivean environment. As the snowpack aged and density increased to 0.2 g/cm^3, then nearly twice as much snow was required for the same thermal protection.

Our index proved to be just the tool we needed to assess the insulative value of different snowpacks. But perhaps of greater importance was the experience we gained collecting the data. What emerged from these studies was a vision of a subnivean world that, under a moderately deep snowpack, is characterized by low but stable temperatures, hovering right at the freezing mark through much of the winter. Even when spring air temperatures warm to well above freezing, the subnivean environment remains near 32° F until the last of the snow melts. (In the Far North, where snowcover may be thin and air temperatures very low, subnivean temperatures may be as low as –23° F.)

How then, in such a constant temperature environment, do plants and animals monitor the progression of the season? What switches on plant growth in a timely manner under the snow, and what told Merritt's voles that it was time to reproduce? Photoperiod, or changing day length, is a nearly universal cue for a number of seasonal developments in plants and animals, so it seems a likely possibility here, too. But how might organisms under a deep snowpack perceive changes in day length? Is snow sufficiently transparent for plants and animals to measure the twilight of dawn and dusk as it shifts with the seasons? More questions.

As I mulled over the possibilities and weighed the available evidence, I became particularly intrigued by one aspect of Merritt's discovery. In the first spring of his study, voles became reproductively active in early March, ten weeks before the mid-May disappearance of the snow cover. During the second winter of his study, the snow accumulated to even greater depths and lasted longer—a full month longer—into mid-June. The onset of reproductive activity under the snowpack was delayed by one month, again commencing ten weeks before the disappearance of the snow. If the voles were keying into seasonal changes in light, they must have been using some measure other than day length.

With this in mind, I began to investigate the light-transmitting properties of snow in closer detail. From the work of Salisbury and his students, I knew that only a small amount of light, principally in the blue and blue-green region of the spectrum, reached the depths of the snowpack. But I also knew that snowpack density influenced light transmission in uncertain ways and that in the spring the snowpack undergoes pronounced structural changes, so I decided to go after more data with the



now buttercups blossom beneath e snow, which then melts around eir open flower petals.
nt and Donna Dannen

elp of my students. We devised a simple xperimental procedure in which we could ompact snow to increasing densities and easure light coming through it with a nsitive silicon photocell, all the while aintaining a constant snow depth.

With the changes in density that natully follow a fresh snowfall, we saw a rogressive decrease in the amount of ght passing through the snow. As we inreased snow density to 0.3–0.4 g/cm^3, alues typical of the upper part of the owpack in late winter, only 2 to 3 perent of the light that penetrated the surface the snow (a very small fraction of the tal incident light) reached a depth of six ches. We compacted the snow as hard as e could, to a density of 0.5 g/cm^3, and early extinguished the light coming rough. We had reached the "critical denty" of snow, the maximum density that n be attained by compaction alone.

Then something interesting happened. obtain still higher densities experimenlly, we warmed our snow to the melting oint, greatly accelerating the coalescence individual grains. We were duplicating process that takes place naturally over me within the snowpack and that is facilated by melting and refreezing in the ring. To our collective surprise, our light tinction curve took an unexpected turn. nce past the critical density, we began to e a small but steady increase in light ansmission. Now, the greater the density, e more light that came through the snow. Vhere light had previously been reacted, scattered, and eventually absorbed y the many tiny ice grains within the owpack, it was now passing through rger, fused grains with much less scatterg and absorption.

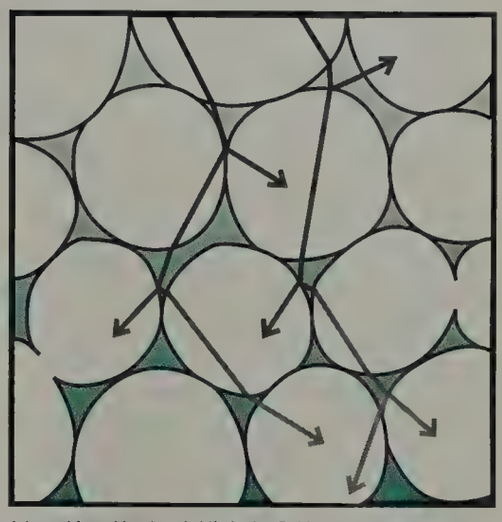
Like most small advances in our underanding, this one came as a revelation, nd it changed my view of the subnivean alm. I now believe that throughout much the winter, organisms confined to the bnivean environment operate in virtual arkness. I calculate that less than 0.1 perent of incident light reaches the ground om late December to early April where ow depth is greater than sixteen inches and density exceeds 0.25 g/cm^3. The increase in ambient light after the winter solstice is offset by continued accumulation and increasing density of the snowpack—until the spring thaw. Once surface meltwater begins to percolate into the snowpack and refreeze, the structure and density of the snowpack change rapidly, and the trend of diminishing light is reversed. Like the coming of spring light in the Arctic, dawn slowly breaks over the subnivean world. This, I believe, must be part of the answer to the timing of endogenous rhythms in plants and animals under the snowpack. It is surely not the only possibility, however.

Another possibility is tied to a curious habit of voles: in many areas, these little rodents construct tunnels through the snow that dead-end at the surface. As Formozov noted in his early writings, "after each fresh snowfall the voles clear these 'windows,' but very rarely come out of them." He postulated that the tunnels "probably serve to ventilate the deeper parts of the burrow." Thereafter all such tunnels became known as "ventilation shafts." The premise here is that carbon dioxide released by soil microorganisms, plant roots, even the voles themselves, eventually accumulates beneath the snow to deleterious levels and that the animals deliberately ventilate the subnivean environment by constructing these tunnels.

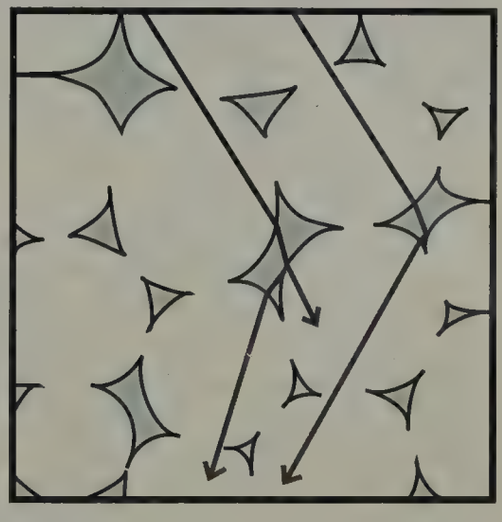
Whether CO_2 accumulation is, in fact, the driving force for the voles' tunnel building, or whether there are other explanations, remains problematical. My students and I have collected air samples from beneath the snowpack with meticulous care, using a pulse pump to draw short breaths of air with as little disturbance to the subnivean atmosphere as possible. We sampled a wide range of habitats under a variety of weather conditions, and we found that under some circumstances CO_2 accumulations did indeed exceed ambient concentrations, sometimes by as much as five-fold (levels twice that high have been reported by others). But we also observed that high levels of CO_2 were usually transient, with the gas diffusing readily through the snowpack, especially on windy days. And in the laboratory we found that the amount of CO_2 accumulating overnight in a ventilated nest-box occupied by a single vole was frequently at least ten times greater than ambient levels. The voles in this case were provided with an escape route to a low CO_2 environment, which they explored frequently when they were active, but while resting they felt insufficient discomfort at the higher CO_2 levels to abandon their nests.

So we are left with the possibility that "ventilation shafts" in nature serve some other purpose. I have excavated many such tunnels, sometimes wondering if the unexplained dips and turns might simply represent random wanderings of restless voles under the snow. One tunnel that I followed nosed twelve inches below the surface and meandered for more than twelve

Light passing through snow crystals, top diagram, is refracted, or bent. As it scatters, some is absorbed. In general, the denser the snowpack, the less the light that gets through. Past a certain density, however, light transmission actually increases; at very high densities ice grains merge, bottom diagram, reducing the total surface area available for refraction and absorption of light.



Adapted from Marchand, *Life in the Cold.*



Unseen but not necessarily unheard, small mammals living beneath the snowpack may not always escape the sharp ears of a fox.
Stephen J. Krasemann, DRK Photo

Pasque flowers are among the first flowers to bloom in the spring. They get a head start under the snow, developing some leaves and flower buds, and are ready to open as soon as the snow melts.
John W. Matthews; DRK Photo

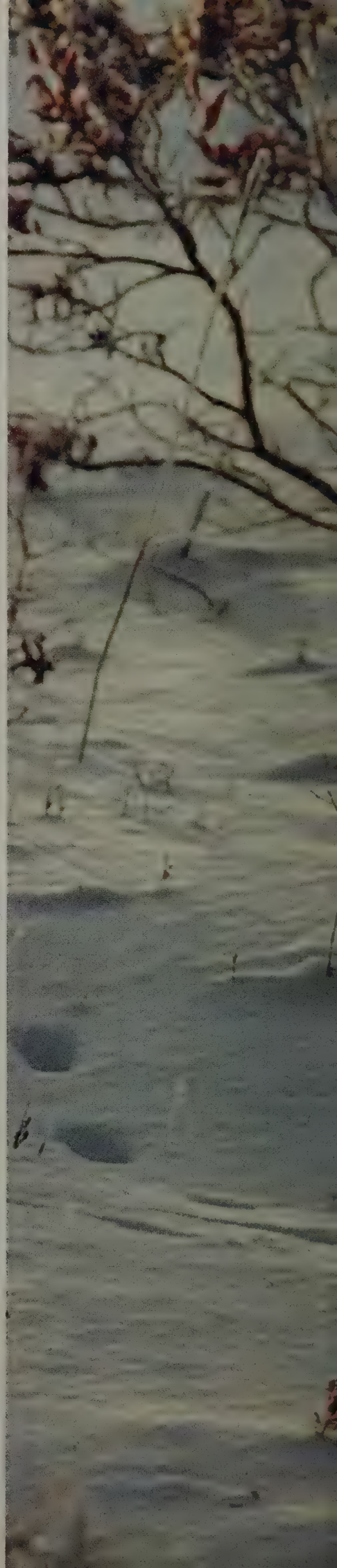


feet horizontally, before plunging to subnivean depths at the base of a willow thicket. I encountered two resting cavities along the way, one sixteen inches and the other nine feet away from the "window"; both had been used considerably, as evidenced by the accumulations of scat.

Whatever drives the voles to construct these tunnels and keep the windows clear, it does bring them to the surface and thus to the daylight. Perhaps, I mused, these frequent excursions to the surface enable the voles to keep track of the changing season, constantly resetting their biological clocks to stay in synchrony with the world above them. However, there are areas where voles are abundant but where tunnels to the surface are conspicuously absent, particularly in deep snow, such as in the Rocky Mountain site where Joe Merritt worked. So I am left with my earlier suspicion that in an environment characterized by constant temperature and unwavering darkness through much of the winter, a spring turnaround in light penetration to the subnivean is somehow of paramount importance in triggering growth and reproduction.

In a fledgling science with unknowns racing far ahead of answers, I am obliged to speculate on one more intriguing question. Could it be that plants are the principal timekeepers of the subnivean world? We know from the research of Salisbury and his students that many plants actively grow under the snowpack; some, like tansy mustard and snow speedwell, germinate from seed, while others, including spring beauty, dogtooth violet, western coneflower, and the common yarrow, all sprout from underground storage organs. A few species, including the appropriately named snow buttercup, even open their flowers into the snow. Undoubtedly much of the chemical energy for this activity comes from utilization of stored reserves, yet the possible role of light-energy penetrating the snow cannot be ignored. The blue and blue-green light measured at the bottom of the snowpack by Salisbury's group is of optimal wavelength for absorption by photosynthetic pigments. And these same researchers have observed chlorophyll synthesis (a chemical reaction requiring light) in leaves under the snow, suggesting that plants may indeed be utilizing some of the energy that filters down from above.

Regardless of energy source, the plant growth processes that Salisbury observed require active metabolism, involving the synthesis of many biochemical compounds, which means that there is chemical information flowing. And there is a growing body of evidence that some of the chemicals regulating growth in plants may directly stimulate reproductive activity in small mammals that ingest them. Gibberellic acid, a growth hormone especially prevalent in germinating seed, is one such compound; and a glycoside derivative present in vegetatively growing young plants (known as 6-Methoxybenzoxazolinone, or 6-MBOA) is yet another compound with demonstrated effectiveness. So perhaps the voles under deep snow cover are getting their information, and the stimulus to breed, from the food they eat. Plants, as receptors of light energy and mediators of biochemical processes in herbivores, may be the ultimate harbinger of spring in the subnivean world. □





Cushenbury Canyon, California

by Robert H. Mohlenbrock

Only fifty miles east of Los Angeles, the San Bernardino National Forest provides a wide range of vegetation, from the creosote bush and burrobrush of the Mojave Desert to the ground-hugging alpine plants that grow above treeline on 11,499-foot Mount San Gorgonio, the highest of the San Bernardino Mountains. Between these extremes are extensive woodlands of pinyon pine and juniper; mixed conifer forests of white fir, sugar pine, and ponderosa pine; and subalpine forests with limber and lodgepole pines. The terrain consists mostly of granite and quartzite rock, punctuated by outcrops of carbonate rock, including limestone and dolomite. These outcrops provide the only home of five very rare plants: Parish's daisy, Cushenbury buckwheat, Cushenbury milk vetch, the San Bernardino Mountains bladderpod, and Cushenbury oxytheca.

The carbonate outcrops lie in a thirty-five-mile band running east–west along the northern slopes of the San Bernardino Mountains, at elevations between 3,500 and 8,000 feet. The five rare plants grow at scattered sites within this zone, most often in the understory beneath pinyon pine and California juniper, alongside the more common mountain mahogany, Mormon tea, and Mojave yucca. All but the San Bernardino Mountains bladderpod can be found in a deeply incised ravine known as Cushenbury Canyon (the bladderpod is confined to adjacent Big Bear Valley).

Parish's daisy is a ten-inch-tall perennial with rose-colored flower heads and narrow leaves covered by soft, silvery hairs. It is named for the nineteenth-century California explorer-botanist S. B. Parish, who first described it and some of the other five rarities.

Cushenbury buckwheat has tiny, white-woolly leaves, which grow in dense mats up to twenty inches wide. In May and June, clusters of cream-colored flowers rise on four-inch-tall stalks above the cushion of leaves; the flowers turn purplish as they begin to wither. The sprawling Cushenbury milk vetch radiates stems



Parish's daisy is one of several species confined to areas of carbonate rock.

Photographs by Marianne Austin-McDermon



The flowers of Cushenbury buckwheat turn purplish as they wither.



Agave, a plant found at the fringes of the Mojave Desert, grows on the floor of Cushenbury Canyon. In the distance, mining operations have exposed an outcrop of limestone.
Noella Ballenger and Jalien Tulley





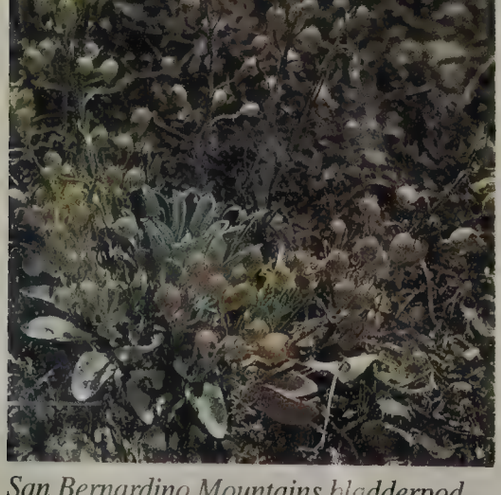


about twelve inches long. Small clusters of purple, sweetpea-shaped flowers appear near the ends of the stems. The San Bernardino Mountains bladderpod is an eight-inch-tall member of the mustard family that bears small yellow flowers, silvery-hairy leaves, and an inflated seed pod. Rarest of all, and the only annual, is the Cushenbury oxytheca, a four-inch-tall, white-flowered plant related to the buckwheat.

The carbonate rock that supports these plants also poses the greatest threat to their survival, for it is a desirable commodity. It is so pure that pharmaceutical companies use it as an ingredient in antacids, and other industries use it in sugar refining and rubber manufacturing, as flux for steel, as a whitener for paper, and for fixing dyes in fabrics. The carbonate is also mined for conversion to cement, including the smooth, final coat applied to swimming pools.

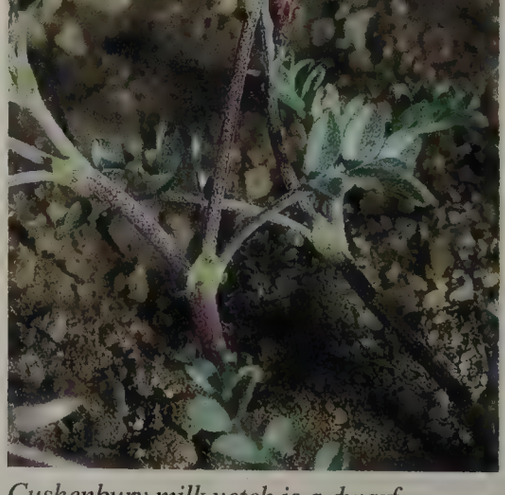
Forest plants are unable to cover the unsightly vertical walls left by mining operations. The mining also generates thirteen tons of waste material for every ton of ore produced. The gigantic piles of overburden that accumulate are inhospitable to vegetation, and "fugitive" dust is readily blown onto surrounding vegetation, soil, and roadways. Adjacent to cement-making operations, a quarter-inch layer of cement often covers the ground and low-growing vegetation.

The five rare plants that grow on the carbonate rock, already barely clinging to existence because of their restricted habi-



San Bernardino Mountains bladderpod grows only in Big Bear Valley.

Photographs by Marianne Austin-McDermon



Cushenbury milk vetch is a dwarf member of the pea family.

Cushenbury Canyon

For visitor information write:
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tat, have little chance of surviving conti
ued mining operations. Before 1975, the
were no federal regulations on what mi
ers could do to the terrain, and even no
the laws on reclamation are weak ar
poorly enforced. As a result, the U.S. Fo
est Service has petitioned the Fish ar
Wildlife Service, the agency that admini
ters the Federal Endangered Species Ac
to list the five plants as endangered
threatened. If this is done, then tho
growing on Forest Service land would b
automatically protected.

The mining companies have mounted
major effort to convince the Fish ar
Wildlife Service not to list these plant
One argument used is that these plants a
not restricted to carbonate rocks and ther
fore could be found elsewhere, b
botanists have no evidence for this. At th
time of this writing, the mining industr
has petitioned for a delay in the decisio
while it attempts to strengthen its case.

In the meantime, the mining industr
continues to take advantage of the ver
outdated 1872 Federal Mining Act, whic
was designed to encourage private ind
viduals and companies to utilize publ
lands more fully. Those who have a plan
carry out mining can apply for a patent
public land. If the patent is approved b
the federal government, the land become
converted to private land at the price
only two dollars an acre.

The mining act of 1872 undermines th
effectiveness of the Endangered Specie
Act, since plants growing on private lan
receive no protection. Land aquired unde
the act might not even be mined. In som
cases, corporations have received patent
on public land under the presumption of
future mining operation, then abandone
the plans in favor of resorts, condomin
ums, and other forms of development.

*Robert H. Mohlenbrock, professor emer
tus of plant biology at Southern Illino
University, Carbondale, explores the bio
logical and geological highlights of th
156 U.S. national forests.*

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Where Late the Sweet Birds Sang

by Michael J. Bean

One of the little-known casualties of this country's race to be first on the moon was a tiny bird found only in the coastal salt marshes near Cape Canaveral, Florida. With the nation's eyes fixed on the heavens, few noticed that a unique form of life was being almost literally crushed underfoot. Mark Walters's account of the decline and extinction of the dusky seaside sparrow is a fascinating story with few heroes and some rather surprising villains.

Walters spent his childhood in Florida near Cape Canaveral and witnessed the beginning of what he calls "the transformation of Brevard County from a jewel to a trinket." Years later, he returned to recreate the final chapters in the history of a bird that had almost certainly survived many storms equal to Hurricane Andrew but not the onslaught of human development. Walters tracked down many of th principal players in this modern conserv tion drama, interviewed them, and metic lously examined their notes and corr spondence. His story is a depressing on recalling the determined and ultimate failed efforts of a few individuals strug gling against bureaucratic lethargy, offici bungling, greed, missed opportunities, ar simple bad luck.

Until 1960, the dusky seaside sparrow salt marsh habitat had been little change by the population growth that was occu ring elsewhere in Florida. After Wor War II, the Air Force had begun operatin



A dusky seaside sparrow in Merritt Island National Wildlife Refuge, 1978
Jeff Foott; Bruce Coleman, Inc.

A SHADOW AND A SONG: EXTINCTION O THE DUSKY SEASIDE SPARROW, by Mar Walters. *Chelsea Green Publishing Co $21.95; 256 pp.*

missile-launching facilities on Cap Canaveral, and their extensive DD spraying of nearby marshes for mosqui control had affected the dusky's popul tion. Nevertheless, when the spraying wa halted in the 1950s because the local mo quitoes had become resistant to DD probably several thousand birds remaine With their habitat still intact, their nun bers might have rebounded, but in 195 NASA began buying up much of the Cap for its planned space center. To build an operate the center, NASA wanted more e fective mosquito control.

The successor to DDT in the unendin war against mosquitoes was physical ma nipulation of the marshes. By diking o the flow of salt water and flooding th marshes with fresh water, they would n longer serve as breeding areas for the mo

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bothersome species of mosquitoes. Freshwater impoundments also attracted many more ducks, and no institution of government has had a longer love affair with ducks than the U.S. Fish and Wildlife Service, to which NASA turned over a major chunk of its marsh holdings to create the Merritt Island National Wildlife Refuge.

Unfortunately, these marshes were one of only two population centers for dusky seaside sparrows, which depended upon marsh grasses that grew only in tidal marshes, not freshwater impoundments. When researchers began linking the continuing decline of the duskies to the way in which the marshes were being managed, the Fish and Wildlife Service ignored the information for fear of alienating both mosquito-minded NASA and its own duck-hunting constituency.

On March 11, 1967, the dusky seaside sparrow became one of the first "endangered species" designated under newly enacted federal legislation. Its select company included the whooping crane, California condor, black-footed ferret, and Florida manatee. Although its chances for survival on Merritt Island were grim at the time it received legal protection, the outlook for the dusky brightened the following year when a second major population center—with more than a thousand birds—was located in the Saint John's River marshes nearby.

Those brightened prospects quickly faded, however, when plans were announced in 1969 to build a highway through the center of the newly discovered habitat. In the opinion of local developers and officials, the space center could be a major tourist attraction in its own right, a side trip for the millions of visitors destined for Orlando's Disney World—if only a new road linking the two sites were built. Walters recounts a series of failures on the part of the Fish and Wildlife Service: to anticipate the explosion of growth that the road would fuel, to take advantage of land acquisition opportunities when it finally recognized the threat, and to manage effectively the parcels of land that it ultimately acquired.

In a few short years the dusky seaside sparrows were nearly gone. The final portion of Walters's book chronicles a last-ditch effort to perpetuate the dusky's lineage with the handful of birds—all males—that were still alive. The idea was to crossbreed the surviving males in captivity with females of a closely related subspecies, and then backcross with t resulting offspring until a nearly "pu dusky resulted. The Fish and Wildlife S vice could not decide whether this w permissible under the Endangered Spec Act and, according to Walters's accou their vacillation, hedging, and dawdli contributed to the dusky's ongoing sli toward extinction.

Ultimately, the Fish and Wildlife S vice washed its hands of the bird, allowi the few remaining captive males to housed at Disney World, where the cro breeding effort would be carried out w strictly private funding. Walters saves final arrow for Disney World. Hinting th their motives from the beginning had be only to garner favorable publicity, Walt alleges that Disney fabricated a story th a storm destroyed the remaining dusky h brids; this story was to cover up the fa that after the last pure dusky, Oran Band, died in 1987, Disney World lost i terest in the project and allowed the hyb offspring to perish through neglect. Lo books that supposedly documented th neglect mysteriously disappeared.

The death of the last dusky seaside spa row on June 16, 1987, was the first extin tion of a North American bird since t

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ssing of the heath hen in Massachusetts
re than a half-century earlier. Only two
nths before, the last California condor
d been taken from the wild as part of a
t-ditch captive-breeding effort. Al-
ugh condors have bred successfully in
tivity, whether they will ultimately sur-
e reintroduction to the wild is an open
estion. One of two captive-bred condors
eased into the wild in 1991 recently per-
ed after drinking from a puddle of an-
eeze near a roadway.

The dusky seaside sparrow and the Cal-
rnia condor illustrate the odds against
rvival for any species reduced to a mere
ndful of members. Yet the raging con-
versy in the Pacific Northwest over the
rthern spotted owl and the future of its
cient forest habitat shows the difficulties
building a consensus for conservation
en a species is still relatively abundant.

Mark Walters's account of the dusky
aside sparrow appears at an important
e. The Endangered Species Act is sud-
nly the object of much public and con-
essional hostility because of controver-
s over the northern spotted owl and
er less-known species. The new Con-
ess that convened in January will con-
er a number of proposals to change the
, including many that would cripple its
lity to stave off extinction for the more
n 700 plants and animals that the act
w protects. Walters's book reminds us
w fragile the present law's protection is
d invites us to ponder whether a weak-
ed law could possibly hold off a torrent
other extinctions.

In his classic work, *A Sand County Al-
nac,* Aldo Leopold wrote that "for one
ecies to mourn the death of another is a
w thing under the sun." Mark Walters's
ok is something newer still, a work of
erature that embodies both journalistic
vestigation and a personal requiem for a
nished life form.

The saga of the dusky seaside sparrow
a riveting tale. Walters is a talented
iter with a keen understanding of nat-
l history. His story of the dusky is both
gedy and farce. Everyone old enough to
d this book once shared the earth with
e dusky, but few ever heard of it and
ver still ever saw it. Yet readers will
are Walters's profound sense of loss that
e dusky seaside sparrow is no more.

*ichael J. Bean, an environmental
wyer, is chairman of the Wildlife Pro-
am of the Environmental Defense Fund
d author of* The Evolution of National
ildlife Law.

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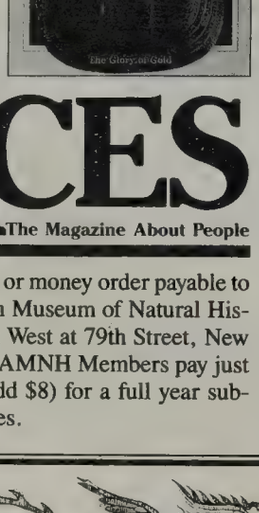
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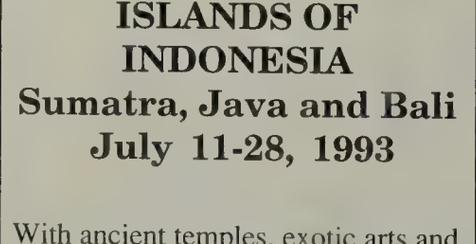
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On the Solar System's Edge

by Gail S. Cleere

In the southwestern sky, brilliant Venus marks the general direction of a newly discovered member of the solar system. The object is impossible to spot without a large telescope, but its location in the sky is near the "circlet" in Pisces. It shares the far reaches of the solar system with Pluto and is only some 125 miles in diameter. Discovered by David Jewitt of the University of Hawaii and Jane Luu of the University of California at Berkeley, the reddish object has been temporarily designated 1992 QB1.

A formal name will not be bestowed on the object until its orbit is better known—perhaps in a year or so. Jewitt and Luu like the name "Smiley" after George Smiley, the John le Carré spy, but the International Astronomical Union, a worldwide organization of astronomers and astrophysicists, will make the final decision.

1992 QB1 represents the first discovery of one of the "planetesimals" or "miniplanets" that are assumed to orbit the sun at a distance one-third to three times as far as the most distant known planet, Pluto—the realm of the so-called Kuiper Belt, a flat disk of large, inactive comets that are thought to be orbiting the sun in the same plane and direction as the planets. 1992 QB1's orbit is more typical of the planets than is Pluto's orbit, which is tilted away from the plane of the ecliptic by almost 18 degrees. (The postulated Oort cloud, which harbors trillions of comets even farther from the sun than the Kuiper Belt, is thought to be the origin of the comets that become visible in our sky. Gerard Kuiper, a Dutch astronomer working in the United States, proposed the existence of the belt's icy fragments, which, he reasoned, would be left over from the formation of the planets.) Largely because of the bitter cold in the far reaches of the solar system, 1992 QB1 has probably changed little since the major planets coalesced out of gas and dust at the birth of our solar system so 4.5 billion years ago.

Jewitt and Luu report that the reddi color of the new object is consistent with surface composition rich in organic mate ial that has been bombarded with cosm rays over the eons. However, Jewitt note 1992 QB1 is so distant that this radiati has changed the object's structure on very slightly over time, making it a gre solar system time capsule of sorts.

After searching the edge of the know solar system for five years, Jewitt and Lu found 1992 QB1 on August 30, 1992. "N one was ever completely comfortable wi the idea that the outer fringes of the sol system could be completely empty," sa David Jewitt. "1992 QB1 is probably primeval remnant of all that early dust a gas."

Astronomer Jim DeYoung, who h been using images taken with the 61-in astrometric (position-measuring) tel scope in Flagstaff, Arizona, to track th object, is one of a handful of scientis who are observing 1992 QB1 with the a curacy needed to help calculate its orb Because of the paucity of observing tim available on the world's largest telescope only a few astronomers—in Hawaii, Ar zona, Texas, and Australia—are observin 1992 QB1.

The Planets in February

Mercury is visible in the early evenin western sky during the latter half of th month. Best viewing will be right aft midmonth, when the planet nears its grea est distance (elongation) from the sun— about 18 degrees east of the sun. Just aft sunset on the 23d, look for a sliver of new moon 3 degrees north of Mercur Venus is high above them both.

Venus steals the show all month long i the southwestern evening skies. It reache its greatest brilliancy of the year on th

h, coming within one-half a degree of moon on the same evening. Watch as nus appears to perch atop the illumi-ed cusp of this four-day-old moon—a at performance on a cold winter ning. The show ends by 8:00 P.M. with setting of the moon. Seen through a scope or binoculars, Venus appears as rescent.

Mars continues to put on a good show the constellation Gemini, where it is l up in the southeast as the sky grows k. The red planet lies almost on a line ween the two bright stars that mark the ns Castor and Pollux and the V-shaped erism called the Hyades in Taurus the l. (Don't mistake Mars for the red star lebaran in the Hyades cluster.) Over the hts of February 1–4 watch as the wax-gibbous moon skims the top of the ades, passes high above Orion the nter, and then glides just below brilliant rs on the 4th.

Jupiter rises about midevening in the stellation Virgo and is up for the rest of night. Around midnight, brilliant piter dominates the southeastern sky, t above the bright star Spica. On the h, the waning gibbous moon passes h the planet and star.

Saturn emerges from behind the sun t before sunrise very late in month, but ost in the solar glare.

Uranus and **Neptune** are to the left of handle of the Sagittarius "teapot," ris-together some two hours before the n. If you know exactly where to look, y may be barely visible with binoculars fore twilight very low on the southeast-horizon. On the 17th and 18th, the ning crescent moon pays a call. The lat-news about Uranus is that it contains ion H_3^+; the discovery was made with eat Britain's infrared telescope on una Kea in Hawaii. The ion is thought be a building block of more complex interstellar molecules in the universe. Dr. Laurence Trafton, a scientist at the University of Texas at Austin's McDonald Observatory, says "Astronomers have been looking for years for this ion in interstellar space to test the hypotheses that H_3^+ plays a central role in the chemical evolution of molecular clouds, where stars are born. All life as we know it requires complex molecules, and we know that when H_3^+ combines with other molecules, it initiates the interstellar chemistry to build bigger molecules. This is a way of going from the simple to the complex." Trafton cautions that scientists have not yet established that the chemistry involving H_3^+ has any relation to the chemistry that led to the building blocks for life on Earth. "It is simply an early step."

Pluto rises about midnight, and by dawn is well above the southern horizon. At 13.7 magnitude, it remains hidden in the constellation Serpens and requires a detailed chart to locate. On February 18, sixty-three years ago, Clyde Tombaugh, a young astronomer from Kansas working at the Lowell Observatory in Arizona, discovered the ninth planet in the solar system while he was looking at photographic plates taken with the observatory's thirteen-inch telescope. After making this momentous discovery, he casually walked down the hill to report his finding to his boss, and then walked to town to see Gary Cooper in *The Virginian.*

The **Moon** is full on the 6th at 6:55 P.M., EST; reaches last-quarter on the 13th at 9:57 A.M., EST; is new on the 21st at 8:05 A.M., EST; and does not reach first-quarter until March 1st 10:46 A.M., EST.

Gail S. Cleere writes on popular astronomy and is a founding member of the International Dark Sky Association, an organization dedicated to preserving the skies for astronomy.

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Shades of Carolina Rice

The coastal plantations are gone, but an African-influenced style of cooking remains

by Raymond Sokolov

"In all these years, she's never wrecked the rice." That nauseatingly condescending line (or something quite like it; I quote from memory) capped a television ad that used to run seemingly every ten minutes in prime time. I haven't seen it lately, but I think it still speaks to our national nervousness about rice. Indeed, throughout northern Europe and many of its former colonies, a lack of assurance and easy mastery of the world's most popular food grain is endemic.

I am not talking about sophisticated preparations. What I'm saying is that if you buttonhole people on the street in New York or Dubuque or Seattle (or London or Mainz or Lyons) and ask them how they cook plain, raw white rice, you will not get a lot of confident replies. All bets are off here if you hit on people of Latin or Asian heritage. For them rice is the staff of life. Their cuisines are built around it, and they know what to do with it in order to produce the kind of rice they like.

The English speaking world is not rice-centered. For us, rice is primarily a starchy side dish, like potatoes; it is almost never the point of the meal, as it almost always is in hundreds of millions of Chinese households. The Chinese language enshrines this dominance of rice in the Chinese diet by making a single word stand both for rice and for food in general: *fan*. In concept, then, a Chinese dish or meal can be construed as rice with other things added for variety of taste and nutrition. Likewise in Japan, *gohan*, the word for cooked rice, is also the word for a meal.

English appears to offer the same synonymy: meal-grain repast. But this is only superficially the case. Meal/repast descends from a word meaning fixed time, as in modern German *mal*, while meal/grain comes from the same root that gives us mill. Meal is grain that has been milled. So for English speakers, the grain-centered diet in the Asian sense is a truly exotic notion. I still have difficulty accepting, for example, that sushi for the Japanese is not identified fundamentally as a raw fish concoction but as mini-cuisine based on rice tossed in specially seasoned (rice) vinegar.

Nevertheless, one American region, the lowlands of South Carolina, does have a rizocentric heritage. Louisiana, a rice-producing state, lives on rice, but not in the overwhelming and unique way that South Carolina did for so long.

Those days are over. They ended along with slavery and the rise of machine-farmed rice on drier land elsewhere. I visited a defunct South Carolina rice plantation for this magazine some years ago, looking for survivals of foodways from antebellum times. The great estate I saw still had working sluices and other remnants of the slave-made-and-maintained rice farm that had once flourished there. The modern owners used the place to hunt birds that fed on the grasses and to fish in the old paddies. It was a haunting sight and the memory of it gives me a slight shiver now when I see a box labeled Carolina rice and realize that virtually no rice comes from the region any more—only the name lingers.

This vanished world has just come to life again, for readers anyway, in Karen Hess's meticulously researched study *The Carolina Rice Kitchen: The African Connection* (University of South Carolina Press, 1992). Hess has combed the records with the energy familiar to readers of h annotated editions of *Martha Washington's Booke of Cookery* and *The Virginia House-Wife*. In the lost wet world of low land Carolina she finds not only a shinin exception to our historical insensitivity rice, but she also documents the cruci link between African and southern Ame ican cooking.

Anyone who cared to think about th matter always knew that certain southe ingredients were brought across the A lantic with slavery and must have perm ated the white menu because black cook put them on the slaveholder's table. Ok is one such African American immigra assimilated into the white cuisine of th Old South. Black-eyed peas have never r ally lost their African flavor. But in Sou Carolina, when mixed with rice in Hop pin' John, they are everybody's emblen atic New Year's dish.

Hoppin' John, okra—the list is easil expanded—were only the most visible ev idence of the influence of black cooks o the South at large. But few people hav suspected, or dared to say, how muc more fundamental black cooking was t the whole rich plantation cuisine that ha survived as the most complete and thriv ing traditional regional menu of the Unite States (the cooking of what is now th Southwest evolved as a northern offsho of Spain's colonization long before Ne Mexico or even Texas had had their co nection fully severed from Mexico).

By segregating contemporary blac cookery as soul food, both black an white enthusiasts have actually underc the importance of Africa in the kitchens o the South, early and late. Anyone wh



oman fans rice by the Santee River, South Carolina, circa 1890.
Rice Museum; Georgetown, South Carolina

cares to take an unprejudiced look at the dishes called southern and the dishes called soul food will be hard pressed to find a significant difference between the two. The cuisines are fundamentally the same, in fact and in origin.

The cooks who evolved the menus for the Big House of slaveholding plantations were black women. Just as in France, noblemen tended to appropriate the creations of their chefs, so too the white culture of the South has taken an unfair share of the credit for southern cooking. This claim doesn't stand up to logical scrutiny, especially when a cursory scan of the recipes in a survey of the Creole cookery of the West Indies such as Elizabeth Lambert Ortiz's *The Complete Book of Caribbean Cooking* (M. Evans, 1973) leads inexorably to the conclusion that United States southern cooking is not unique to our southeast. It is the northernmost extension of a continuum of dishes common to all the slaveholding territories of the Atlantic and Caribbean New World. The similarities can only be explained by the single factor common to every one of these colonies, whether French, Spanish, English, or Dutch in governance: African slaves.

The transatlantic commerce in people led to a transplantation of their foodways and then to a creative adaptation to new conditions and new ingredients. Viewed this way, the hush puppy of our South is a first cousin of the *acaraje* of Brazil, with cornmeal substituted for black-eyed pea flour. Both are deep-fried. We might say "southern-fried." This is the conveniently nonracial term we use for our most popular native dish: chicken that has been

dredged in flour and fried. But southern frying is not a method that can properly be claimed as ours. The entire Creole (read: ex-colonial slaveholding) New World survives on southern-fried fish and vegetables and fritters.

Hess shows how the settlers of Carolina brought the island Creole culture with them from Barbados and the Bahamas in the seventeenth century. They brought their slaves and a Creole attitude born of a century of colonial life in the islands. Almost half of them, moreover, were French Huguenots. Many of their slaves already understood rice culture and cookery, because they came from the rice lands of Africa. When they saw the rivers of the Carolina low country, they knew what to do. Carolina rice was the famous result.

In the kitchen, they built a New World regional cuisine around rice. That is Hess's main subject. She weaves a fine web of careful speculation about the path that rice took to Africa and how the non-African rice dish pilau made its long, slow way to Charleston.

Her thesis maintains that rice followed Islam westward through Malay-speaking Madagascar across Africa to the rice lands of West Africa, the region that was also the original source of the slaves who were forced to work New World fields. This route of transmission, Hess argues, brought to Carolina people accustomed to cooking rice in a special style peculiar now to Carolina tradition and to India (and food cultures related historically to India).

The basic biology of rice lies behind this connection. Both India and plantation South Carolina evolved cuisines based on long-grain rice. There are many other varieties of rice in the world, each of which has special cooking qualities (Italy's short-grain rice lends itself to the gradual absorption of stock in risotto, Spain's medium-grain rice behaves similarly in the restricted environment of the paella pan). But long-grain rice is the main staple of Asia's billions, who have settled, as Hess acutely observes, on two radically different methods of cooking it: the Indian and the Chinese.

In the Chinese method, a measured quantity of rice is combined with a measured quantity of salted water (conventionally in the ratio, by volume, of one to two, although somewhat less water probably yields better results). After the water boils and cooks the rice to the point where most of it has been absorbed, and steam holes appear on the surface, the pot is covered, heat reduced to almost nothing and the rice left to steam for several minutes until all the water is absorbed.

This is the more energy-efficient method, and it is the world's favorite. However, it produces a slightly sticky rice, ideal for consumption with chopsticks, rather than the completely separate, fluffy grains created by the Carolina/Indian method.

That basic method is: Bring a large, unmeasured quantity of salted water to a full boil. Then add an unmeasured quantity rice but one that is much smaller than t volume of boiling water. Cook over hi heat for five to ten minutes. Drain t water. Return the rice to the fire, cover t pan, reduce the heat to very low, a "soak" until done.

Raymond Sokolov is a writer whose sp cial interests are the history and prepa tion of food.

Medium-Grain Rice:
The Spanish Method

Arroz con magro de cerdo y habas
Rice with Pork and Fava Beans

(Slightly adapted from *The Heritage of Spanish Cooking,* by Alicia Rios and Lourdes March, Random House, 1992)

¼ cup olive oil
½ pound lean pork, diced
13 ounces shelled fresh fava bean
1 tomato (3 ½ ounces), peeled and finely chopped
1 teaspoon paprika
5⅔ cups chicken or beef broth
1 pinch saffron
Salt
1⅓ cups medium-grain rice

1. Heat the oil in a casserole. Fry the diced pork, followed by the fava beans and tomato. Add the paprika, followed immediately by the broth.
2. Cook for 15 to 20 minutes, according to the tenderness of the beans, then add the saffron.
3. Check the seasoning, add salt to taste, then add the rice and cook uncovered over medium heat for 16 to 18 minutes. Taste the rice to check that it is ready. Remove from the heat and serve immediately.

Yield: 4 servings

Short-Grain Rice:
The Italian Method

Risotto with Celery

(Slightly adapted from *Essentials of Classic Italian Cooking,* by Marcella Hazan, Knopf, 1992)

5 cups homemade beef broth or 1 cup canned beef broth diluted with 4 cups water
3 tablespoons butter
2 tablespoons vegetable oil
½ cup chopped onion
2 cups celery stalk, diced very fine
1 tablespoon chopped leafy tops of the celery heart
2 cups imported Italian risotto [short-grain] rice
Salt
Black pepper, freshly ground
⅓ cup freshly grated parmigiano-reggiano cheese
1 tablespoon chopped parsley

1. Bring the broth to a very slow, steady simmer on a burner near where you'll be cooking the risotto.
2. Put 2 tablespoons of the butter, the vegetable oil, and the chopped onion in a broad, sturdy pot. Turn heat to medium high. Cook and stir the onion until it becomes translucent, then add half the diced celery stalk, all the chopped leaves, and a pinch of salt. Cook for 2 or 3 minutes, stirring frequently to coat the celery well.
3. Add the rice, stirring quickly and thoroughly until the grains are coated well. Add ½ cup of simmering broth and cook the rice, stirring constantly with a long wooden spoon, wiping the sides and bottom of the pot clean as you stir, until the liquid is gone. Never stop stirring, and be sure to wipe the bottom of the pot completely clean frequently or the rice will stick to it. When there is no more liquid in the pot, add another ½ cup, continuing always to stir as before. Maintain heat at a lively pace.
4. When the rice has cooked for 10 minutes, add the remaining diced celery, and continue to stir, adding broth a little at a time.
5. Cook the rice until tender but firm to the bite, with barely enough liquid remaining to make the consistency somewhat runny. Turn off the heat, add a few grindings of pepper, the remaining tablespoon of butter, and all the grated parmigiano, and stir thoroughly until the cheese melts and clings to the rice. Taste and correct for salt. Mix in the chopped parsley. Transfer to a platter and serve promptly.

Yield: 6 servings



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"JUMBO" FILM FESTIVAL

In conjunction with the Museum's current exhibition "Jumbo: The World-Famous Elephant," six films about elephants will be presented in the Linder Theater on Saturday, February 6, starting at 10:30 A.M. The films, which are free with Museum admission, are *Horton Hatches the Egg, Dumbo, Maya, Babar's First Step, Elephant Boy,* and *Billy Rose's Jumbo.*

A SCI-FI CLASSIC

February's feature in the classic science-fiction film series will be *This Island Earth.* In the 1955 production directed by Joseph M. Newman, earthlings find themselves trapped on a planet being bombarded by meteors from another planet. The film is preceded by a thirty-minute slide show hosted by Brian Sullivan, the Hayden Planetarium's production designer, and will be shown on Saturday, February 6, at 3:00 P.M. in the Kaufmann Theater. Tickets are $7 ($4 for members).

AN AMERICAN ROMANCE

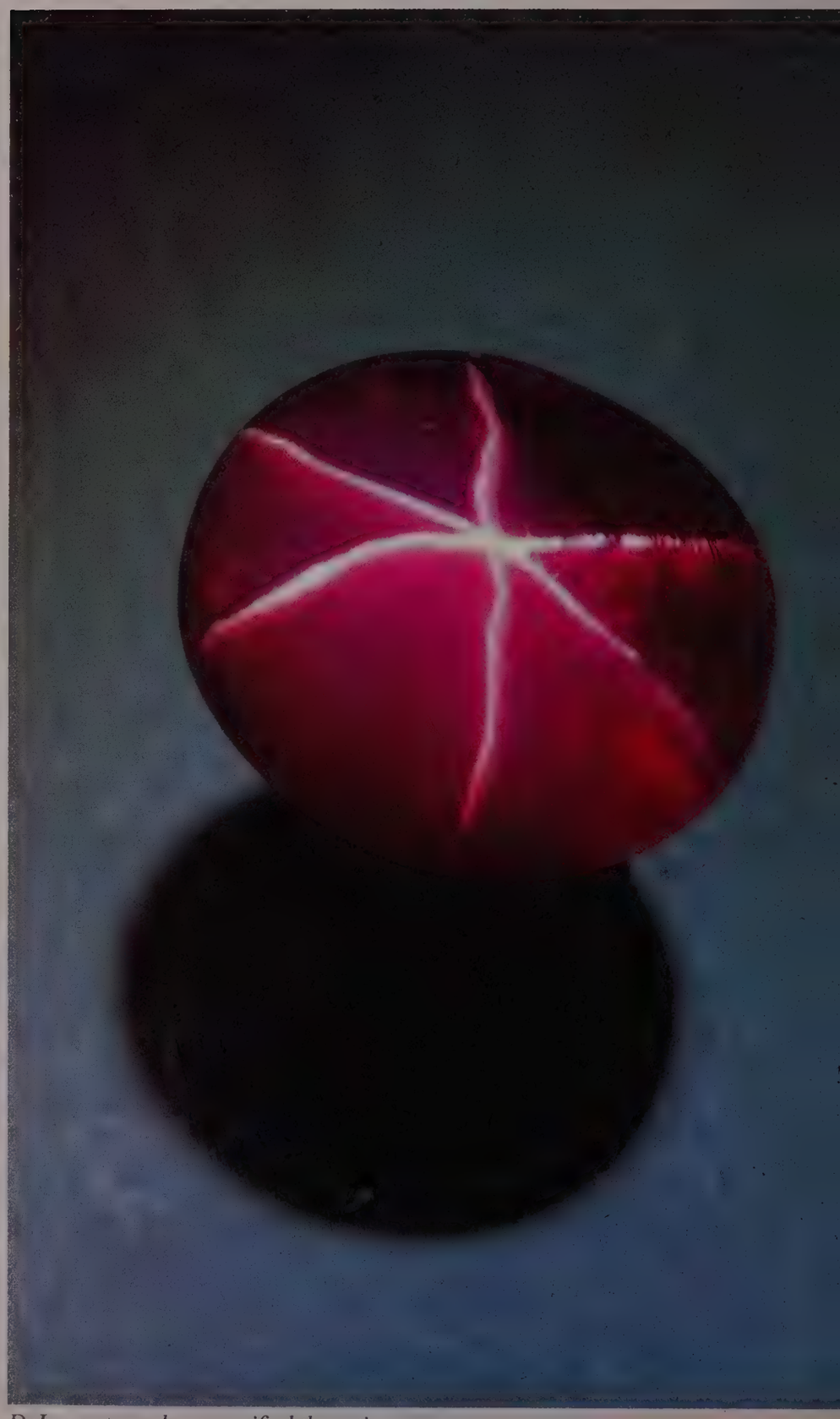
The relationship of photographer Alfred Stieglitz and artist Georgia O'Keeffe is the subject of a lecture by Benita Eisler, a writer and editor who has just completed *O'Keeffe-Stieglitz: An American Romance.* She will speak in the Kaufmann Theater on Wednesday, February 10, at 7:00 P.M. Tickets are $10 ($6 for members).

UNDERSTANDING ANIMAL WAYS

Naturalist Bill Robinson returns to the Museum for a thirteenth year to present "The World of Animals," for children five years and up, on Saturday, February 20, at 11:30 A.M. and 1:30 P.M. Robinson will appear on stage with a legless lizard, an alligator, a snapping turtle, an armadillo, a Burmese python, and other live animals. Tickets are $8 ($5 for members).

RIO ROOSEVELT EXPEDITION—1992

Tweed Roosevelt participated in a joint Brazilian–American expedition last year that retraced his great-grandfather Theodore Roosevelt's 1914 exploration of the River of Doubt (later renamed Rio Roosevelt). On Thursday, February 25, at 7:0[illegible] P.M. in the Kaufmann Theater, Tweed



DeLong star ruby, magnified three times
Harold and Erica Van Pelt

Roosevelt will talk about his adventure down the Amazon tributary. Tickets are $10 ($7 for members). Call (212) 769-5606 for ticket availability.

Quincentennial Perspectives

The Museum's education department continues its free programs from a non-European perspective for the Columbus Quincentenary.

Traditional jazz and African dance will be performed by the Savoy Swingers and by Message From Our Ancestors in the Main Auditorium on Thursday, February 4, at 7:30 P.M.

In the Linder Theater: Chinese-American writers will read selections from their works on Friday, February 5, at 7:00 P.M. Writers include David Wong Louie, Stephen Lo, Fae Myenne Ng, and Linda Ching Sledge. On Sunday, February 28, at 2:00 and 4:00 P.M., C. Scoby Stroman presents poetry, dance, slides, and videos showing African American contributions to folk art.

In the Kaufmann Theater: Mickey D. and Friends will give an African American presentation that includes plantation slave dances, 1940 "barbershopsanding," and ballroom duets on Sunday, February 7, at 2:00 and 4:00 P.M. On Sunday, February 14, at 2:00 P.M., University of Colorado's Evelyn Hu-DeHart, professor of history and director of the Center for Studies of Ethnicity and Race in America, will talk about Asians in the Americas, their immigration, settlement, and relationship with other ethnic groups. Kimati Dinizulu and the Kotoko Society will offer "Sankofa," a musical genre of the African diaspora played on instruments like the *abeng* (warrior horn) of Jamaica and the *vaccine* (bamboo trumpet) of Haiti on Sunday, February 21, at 2:00 and 4:00 P.M.

In the Leonhardt People Center: folk music by the West African Akyene Baako Ensemble, blues dance forms by the Urban Griot Society, and Dorothy Henderson and the B-1 Storytellers' dramatization of the story of the Middle Passage will be among the events presented every Saturday and Sunday in February from 1:00 to 4:30 P.M.

These programs are made possible in part by grants from The Chase Manhattan Bank, Citibank, the Samuel and May Rudin Foundation, Vidda Foundation, and the family of Frederick H. Leonhardt. For a complete schedule, call (212) 769-5315.

African American Cemeteries

Recent cemetery excavations that have added to what is known about New York City's early African American community will be highlighted in three Monday evening lectures, beginning February 22. Cheryl Wilson, urban historian and anthropologist, will host the programs. Series tickets are $30. Call (212) 769-5305.

The Niger River's Ancient Cities

Rice University professor of anthropology Roderick J. McIntosh will give a slide-illustrated talk about the recently discovered city mounds and funerary tumuli of the Niger River floodplain on Tuesday, February 23. Tickets are $15. Call (212) 769-5305.

Cross-Cultural Films

How filmmakers have represented other cultures will be explored in scenes from documentary classics on three Tuesday evenings beginning February 23. Elaine Charnov, programmer of the Margaret Mead Film and Video Festival, will host the event, which will include *Chang: A Drama of the Wilderness, Grey Gardens, Babakiuria,* and *Harold of Orange*. Series tickets are $30. Call (212) 769-5305.

Wonderful Wildflowers of the Northeast

From carnivorous bog plants to arctic creepers, the northeastern United States is home to thousands of species of wildflowers. William Schiller, lecturer in botany for the Museum's education department, will give two identical series of five slide-illustrated lectures, the first on Mondays at 2:30 P.M. beginning February 22, and the second on Thursdays at 7:00 P.M. beginning February 25. Series tickets are $40. Call (212) 769-5305.

The Museum's Gem Collections

Joseph J. Peters, senior scientific assistant in the Department of Mineral Sciences, will talk about four sections of the Museum's gem collections: diamonds; emeralds, rubies, and sapphires; semiprecious gems; and ornamental and organic gems. Tickets for the series of four Thursday evenings, starting February 25, are $35. Peters will also lead a tour of the J.P. Morgan Memorial Hall of Gems on Friday, February 26. Tickets are $15. Call (212) 769-5305.

Young Scientists in Training

Ten high-school juniors started doing research recently under a new program, the Precollege Science Collaborative for Urban Minority Youth, at the American Museum of Natural History. Over the next five years, thirty-five students will design their own two-year projects at the Museum in biology, paleontology, and ecology. Scientists from the Museum and Columbia University's Teachers College will be mentors to the students in twice-weekly sessions and colloquia throughout the school year. The Howard Hughes Medical Institute provided support for the program.

Under the Stars

Performers Cheryl Byron and Something Positive will dance, play music, and tell traditional African sky lore under the Planetarium's star-filled dome. The program will be on Tuesday, February 16, at 7:00 P.M. Tickets are $10 ($8 for members).

As part of the Planetarium's ongoing lecture series, Margaret Geller of the Harvard Smithsonian Astrophysical Observatory will give an illustrated talk, "Mapping a Large Scale Structure of the Universe" on Wednesday, February 10, at 7:30 P.M. in the Sky Theater. Tickets are $8 ($6 for members).

For information about Planetarium events, call (212) 769-5900.

These events take place at the American Museum of Natural History, located on Central Park West at 79th Street in New York City. The Kaufmann and Linder theaters and the Leonhardt People Center are located in the Charles A. Dana Education Wing. The Museum has a pay-what-you-wish admission policy. For more information about the Museum, call (212) 769-5100.

Storm Warming

Unfazed by a March snowstorm in southern Minnesota, a great horned owl patiently warms its eggs round-the-clock in the hollow of an old oak.

Great horned owls begin their annual courtship rituals in the dead of winter. By February, a hawk's abandoned stick nest or a large tree hollow is readied, and by March it holds two or three whitish eggs.

After a month of incubation, the hatchlings, born with an appetite for meat, are introduced to carnivory. The parents feed the owlets for about six weeks in the nest (this parent's constancy paid off; two young left the nest in May). They continue to supply food for a few weeks after the owlets leave the nest and begin learning to hunt.

To accommodate the rapidly growing young and the food delivered by their parents, the nest must be roomy. In his *Life Histories of North American Birds of Prey*, Arthur Cleveland Bent tells of one great horned owl nest that contained eighteen pounds of fare: "a mouse, a young muskrat, two eels, four bullheads, a Woodcock, four Ruffed Grouse, one rabbit, and eleven rats."—*J. R.*

Photograph by Scott W. Sharkey

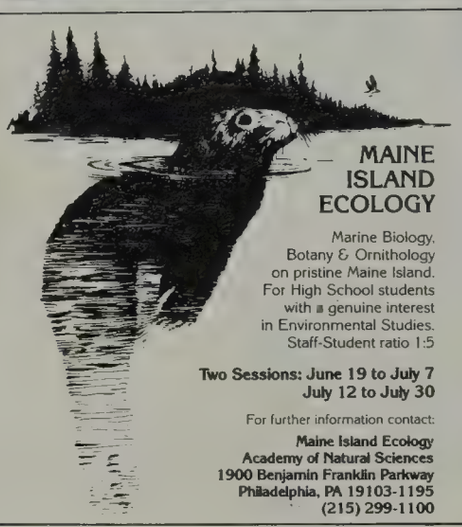




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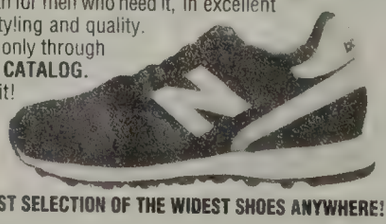
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After studying snowshoe hares in Maine as an undergraduate, **Mark O'Donoghue** (page 26) went to West Africa, where he worked as a wildlife biologist for five years. Drawn to the north again, he moved to Canada and became a Ph.D. candidate at the University of British Columbia. O'Donoghue is studying the responses of coyotes and lynx to changing snowshoe hare densities in the Yukon. Wife and coauthor **Susan Stuart** studied coyotes at the College of the Atlantic in Bar Harbor, Maine. While she remains interested in wildlife, her main a tivity is spinning fibers, including qivi (muskox fur), into yarns and then dyei designing, and knitting them into clothi A readable review of the snowshoe ha cycle can be found in L. B. Keith's *Wi life's Ten-Year Cycle* (Madison: Univers of Wisconsin Press, 1963). For a furth discussion of how different methods rearing offspring develop, the authors su gest T. H. Clutton-Brock's *The Evoluti of Parental Care* (Princeton: Princet University Press, 1991).

When **Nina J. Root** (page 34), director ibrary services for the American Mu- m of Natural History, gathered infor- ion for a biography of the nineteenth- tury natural history illustrator Joseph lf, she combed the rare book collec- ns of the American Museum, the ithsonian Institution, and the British seum of Natural History. "In the rse of my research," she said, "I found Wolf painted a hippopotamus named aysch both as an infant and as an adult. came curious about Obaysch and was ntually captivated by the animal's bi- aphy." A graduate of Hunter College



Pratt Institute, where she took her ster's degree in library science, Root directed the American Museum's li- y since 1970. For the past two years, has overseen the building of the Mu- m's $11 million library, which houses r a million volumes. For further read- on Obaysch, she recommends *The Ark he Park; the zoo in the nineteenth cen-* by Wilfrid Blunt (London: Hamish nilton, 1976).

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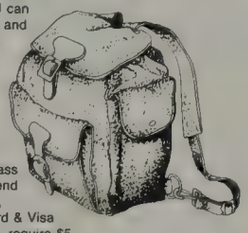
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Why is this man wincing? **Scott W. Sharkey** (page 76), attempting to photograph a great horned owl's nest, explains: "I had gotten only ten feet up the nest tree when the female attacked with a vengeance and knocked me out of the tree. The torn shirt is from her talons." But owls are still one of Sharkey's favorite subjects. He photographed the nesting owl in the "Natural Moment" from the safety of a convenient hillside. At eye level with the nest, which was some twenty-five feet up in a huge oak, he used a Nikon camera with a 400mm lens. An assistant professor of medicine at the University of Minnesota in Minneapolis, Sharkey considers photography a serious hobby. He has been interested in owls since high school when his family "learned that great horned owls do not make good pets." Sharkey considers owls to be the most successful urban raptors and often photographs them in local parklands.





On a trip to Jamaica in 1966, **Margaret M. Stewart** (page 42) turned over a pile of coconut husks and watched, entranced, as dozens of *Eleutherodactylus* frogs jumped out. "I had never seen so many frogs in so small a space," she recalls. The Jamaican species is shy and difficult to observe, however, so Stewart turned to the related coquí, which is abundant in Puerto Rico. Since 1979, she and her graduate students have worked intermittently at El Verde Field Station in the Caribbean National Forest. "Everyone in Puerto Rico knows the coquí," she says, "because it is everywhere, calling from window screens and planters in hotel lobbies and chorusing from the marshes underneath arriving je at the airport." A professor at the Sta University of New York in Albany, Ste art grew up in North Carolina and studi frog ecology in Africa for her thesis. Wh she is not "frogging," she enjoys photo raphy, baroque music, and gardening. F more reading, see Juan A. Rivero's *L Anfibios y Reptiles de Puerto Rico,* in En lish and Spanish (Puerto Rico: Editor Universitaria, Universidad de Puerto Ric 1978). For more information on coquí see "Arboreal habitat use and parachuti by a subtropical forest frog," by Marga Stewart, *Journal of Herpetology,* vol. 1 pp. 391–401, 1985.

Peter J. Marchand (page 50) says he has loved snow since his Massachusetts childhood and has just found different ways to play in it as he has grown older. He got serious about snow while conducting a winter study at the timberline of Mount Washington for his doctorate at the University of New Hampshire. Marchand was associate professor of ecology for ten years at Johnson State College and also became associate director of the Center for Northern Studies, both in Vermont. He then founded and now directs Southwestern Field Studies, an organization that investigates alpine and desert ecosystems. His current research revolves mainly around plants and animals in the winter, but now that he is living in the desert, Marchand has become intrigued by the problems of plants and animals during hot summers. For more on winter ecology, readers may turn to Marchand's *Life in the Cold* (Hanover: University Press of New England, 1991) or *Winter: An Ecological Handbook,* by James C. Halfpenny (Boulder: Johnson Books, 1987).



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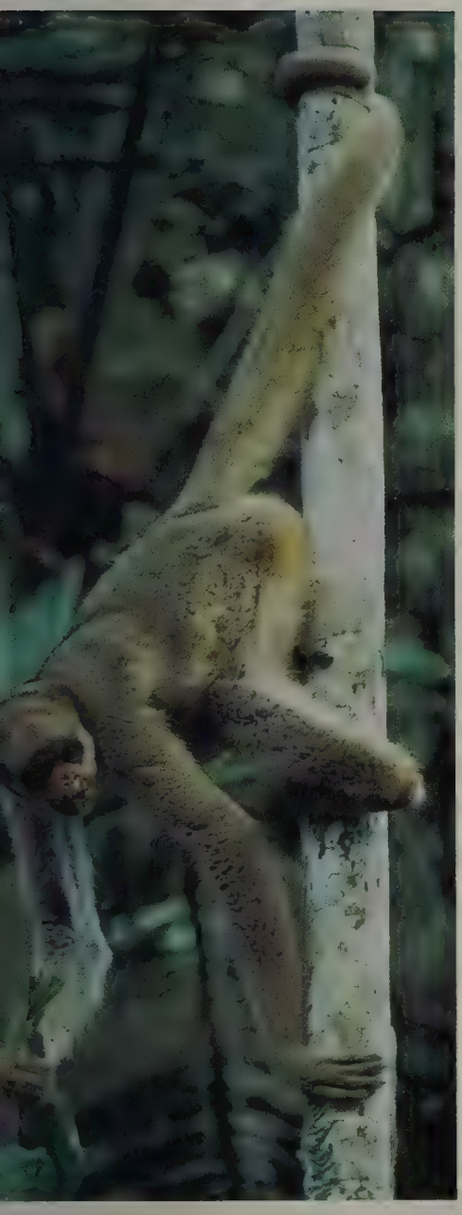
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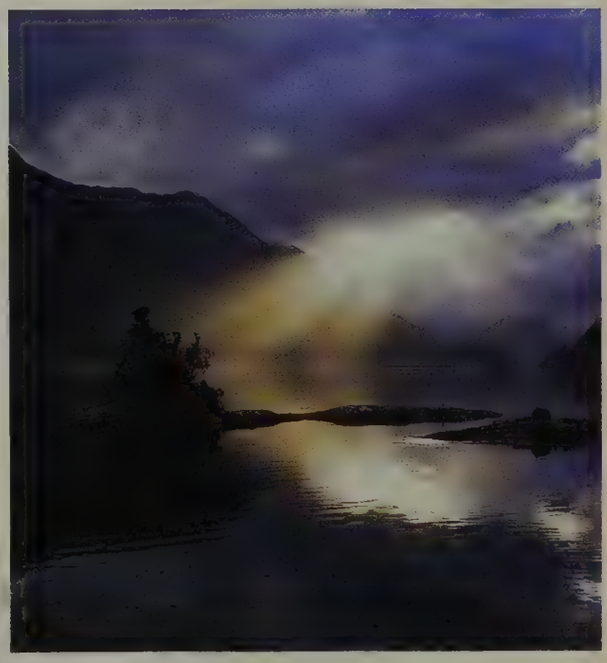
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LETTERS

THE EGG AND GOULD

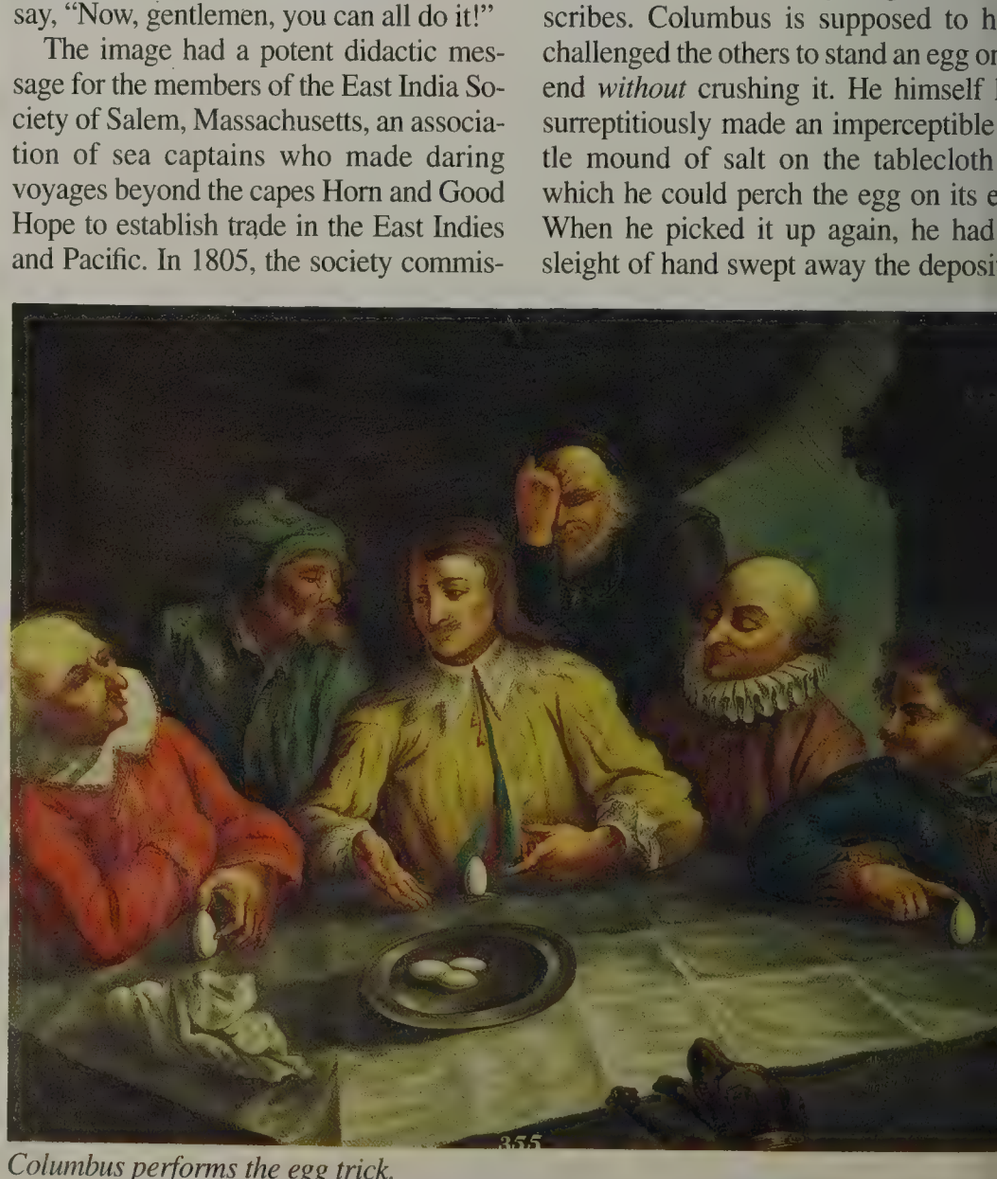
I was surprised to read in the December 1992 issue that Stephen Jay Gould could find no colleagues in the "not so rarefied and intellectual" environment of Cambridge, Massachusetts, who could solve the mystery of Columbus and his egg. Had he queried this Cambridge resident, he would have learned not only the story but also a popular method by which the lesson was taught.

A number of early nineteenth century paintings in the Peabody and Essex Museum collection portray Columbus and his nonplused dinner companions as he performs his feat. In all of them, he gestures toward the vertically oriented egg as if to say, "Now, gentlemen, you can all do it!"

The image had a potent didactic message for the members of the East India Society of Salem, Massachusetts, an association of sea captains who made daring voyages beyond the capes Horn and Good Hope to establish trade in the East Indies and Pacific. In 1805, the society commissioned the artist Michele Felice Corn
paint a copy of a then well-known im
by William Hogarth showing Columb
lesson to adorn their meeting hall. To
East India Marine Society, Columbus
a hero who had accomplished for the
time what others would repeat later v
ease.

DANIEL FINAM
Salem, Massachus

Stephen Jay Gould's version is not
story I heard almost seven decades
when I attended the West Buckl
School in Devonshire, England. Yes
was indeed a con job, but much more s
tle than the trick that young Gould
scribes. Columbus is supposed to h
challenged the others to stand an egg or
end *without* crushing it. He himself
surreptitiously made an imperceptible
tle mound of salt on the tablecloth
which he could perch the egg on its e
When he picked it up again, he had
sleight of hand swept away the deposi



Columbus performs the egg trick.
Peabody and Essex Museum

with his little finger, so that they ldn't see how he did it. Yes, a con, but ore clever con, one that they could not licate.

B. Orchard Lisle
Fort Worth, Texas

believe I encountered the legend ietime between ages ten and fourteen le living in the blue- and white-collar urb of Lyndhurst, New Jersey. In my oolboy version, Columbus performed feat *before* his first voyage. At some of gathering, perhaps in the presence Ferdinand and Isabella, he was asked v the earth could stay in place if it were nd, as he stoutly maintained (implying, iess, that if it were round, it would roll ay). Whereupon Columbus performed cracked egg trick (presumably just to t up a crank so he could get on with his h for support).

Lawrence J. Hall
Bethesda, Maryland

Many of your readers probably first en- ntered the Columbus-and-egg story, erred to by Darwin and cited by phen Jay Gould, in their college Eng- class. In Part 4 of "The Bear," William ulkner described how "men snarled r the gnawed bones of the old world's rthless evening until an accidental egg covered to them a new hemisphere."

Victor Strandberg
Durham, North Carolina

EPHEN JAY GOULD REPLIES:

have never before had so much fun m the correspondence engendered by essay. More than fifty letters have come way, filled with as many versions of story about Columbus and his egg. The at majority come from older readers ost of European backgrounds), thus af- ning my key claim that the story has sed among us indigenous young 'uns less we had access, as I did not, to the source that keeps the tale sputtering o this generation—the 1949 film *ristopher Columbus,* starring Fredric March in the title role. Halliwell's *Film Guide* labels it "an extraordinarily tediously paced historical account of basically undramatic events"—prominently featuring the egg scene, no doubt. *Time* magazine, in a contemporary review, wrote: "Even ten-year-olds will find it about as thrilling as an afternoon spent looking at Christmas cards." So Columbian film flops are no new phenomenon, and Mr. March did not win immortality with the egg).

I was most struck by the extraordinary diversity among my correspondents' versions of the tale, and in their interpretations of its message—a standard circumstance for "canonical stories." Basically, my letters divide about equally into three different versions—(1) that Columbus hard-boiled his egg while the others tried raw eggs; (2) that Columbus cracked the shell (either surreptitiously or with panache, depending upon your interpretation); (3) that Columbus secretly dumped a pile of salt on the table, then placed the egg in the pile and blew the unneeded grains away.

Literary references abound: Tolstoy treated the incident as a joke in *War and Peace*. Faulkner obviously took it more seriously, as Mr. Strandberg's letter attests. Sherwood Anderson, in his 1921 story *The Egg,* agrees with my reading of trickery. One character exclaims: "That Christopher Columbus was a cheat.... He talked of making an egg stand on its end. He talked, he did, then he went and broke the end of the egg." Anderson had been weaned on version two. (My thanks to Donald Fiene of Knoxville for this source.)

But the most interesting and revealing tidbit comes from Vincent Zichello of New Rochelle, New York, who has gratified me no end by proving that the story is a canonical tale with versions predating Columbus, thus illustrating my main argument of the following month's essay (January 1993 on Haldane's beetle remark)—that more famous figures "attract" old legends and that such tales teach us more about the literary biases of preferred modes in storytelling than about historical fact. Giorgio Vasari, in his *Lives of the Most Eminent Painters, Sculptors, and Architects,* written in 1546, tells a tale of the selection of Filippo Brunelleschi to build the dome of the Florence cathedral:

> [He proposed] that whosoever could make an egg stand upright on a flat piece of marble should build the cupola.... Taking an egg, therefore, all those masters sought to make it stand upright, but no one could find the way. Whereupon Filippo, being told to make it stand, took it graciously, and giving one end of it a blow on the flat piece of marble, made it stand upright. The craftsmen protested that they could have done the same; but Filippo answered, laughing, that they could also have raised the cupola, if they had seen the model or the design. And so it was resolved that he should be commissioned to carry out this work.

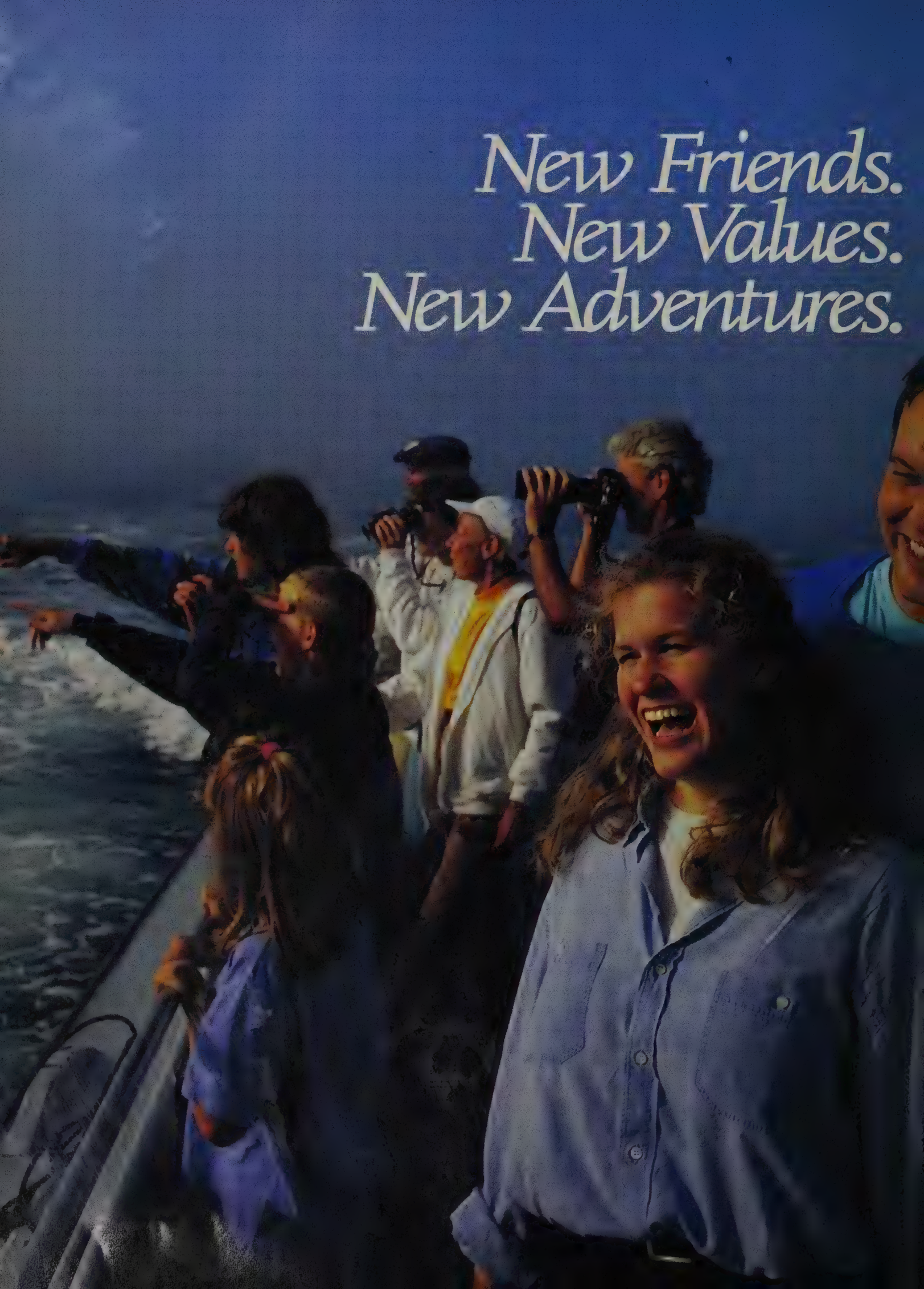
Thus, Vasari placed version two in 1420, when this incident occurred, thirty-one years before Columbus's birth—although I suppose that Phidias tried the same caper when doubters told him that his great statue of Athena would surely collapse under its own weight.

NABOKOV AND MERIAN'S BUTTERFLIES

Maria Sybilla Merian's art had Russian connections far beyond those mentioned by Sharon Valiant in her fascinating essay, "Questioning the Caterpillar" (December 1992). The Russian-American author Vladimir Nabokov owed at least some part of his lifelong interest in butterflies to Merian's work.

An eight-year-old Nabokov discovered her *Metamorphosis Insectorum Surinamensium* in the attic of his family's summer house near Saint Petersburg. As Nabokov later wrote, he "dreamed" his way through these exotic volumes. Lovingly described butterflies are a motif in much of Nabokov fiction and are the subject of an entire chapter in his *Speak, Memory,* where he tells of his childhood encounter with Merian's books.

D. Barton Johnson
Santa Barbara, California

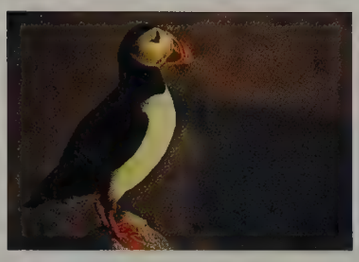

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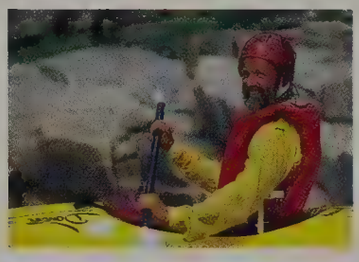
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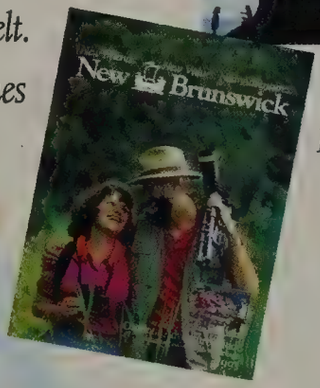
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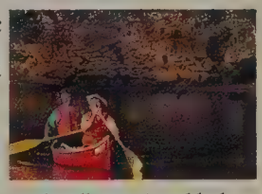
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With My Daughter

In mountainous Iran, an anthropologist's five-year-old child adapts quickly to pastoral life

by Lois Beck

In May 1991, my five-year-old daughter, Julia, and I traveled to southwestern Iran, where I was resuming anthropological research among Qashqa'i nomadic pastoralists. The nomads and their sheep and goats were at their summer pastures high in the Zagros Mountains, at an elevation of approximately 9,000 feet. I had lived with this same group of people for more than a year in 1970 and 1971 and for shorter periods in 1977 and 1979. Since 1978, Iran had experienced a revolution, an Islamic government had taken power, and a devastating eight-year war with Iraq had been waged.

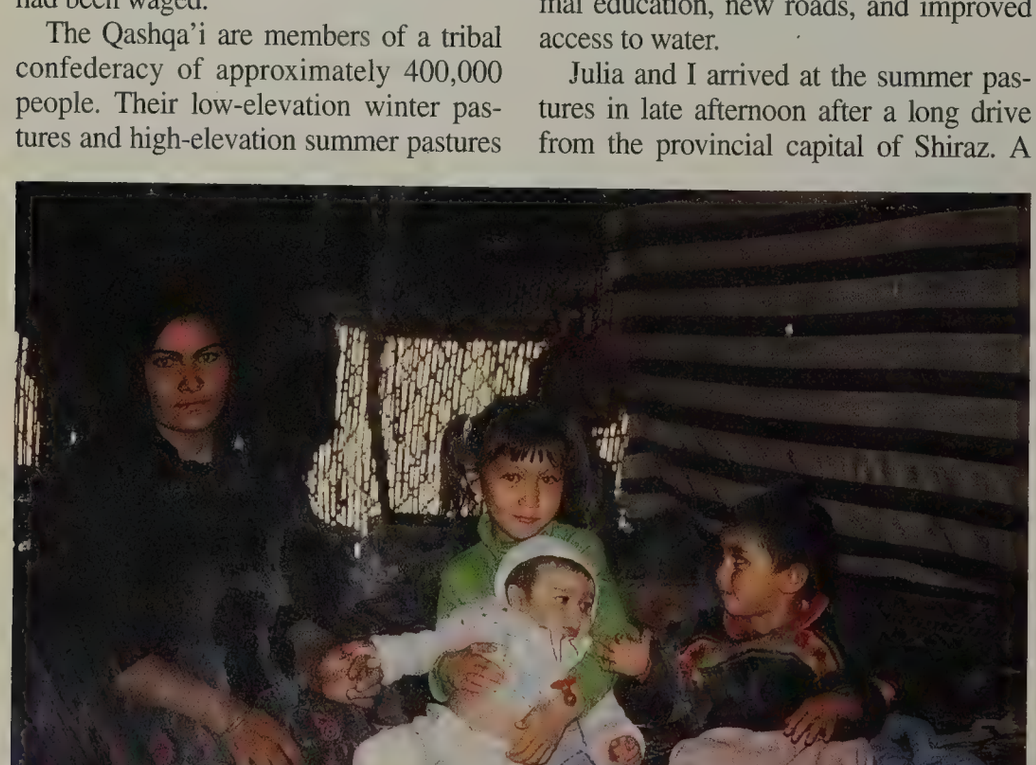
The Qashqa'i are members of a tribal confederacy of approximately 400,000 people. Their low-elevation winter pastures and high-elevation summer pastures are separated by hundreds of miles, and each spring and autumn migration between the two areas lasts from two to three months. One of Iran's many ethnic minorities, the Qashqa'i speak Turkish and are Shi'i Muslims. In the 1960s and 1970s, the regime of Mohammad Reza Shah had pressured many Qashqa'i to abandon nomadism and settle in villages and towns. More recently, the current government has attempted to reverse this policy, and a high-level state agency is endeavoring to provide the nomads with such benefits as veterinary services, modern medicine, formal education, new roads, and improved access to water.

Julia and I arrived at the summer pastures in late afternoon after a long drive from the provincial capital of Shiraz. A new, paved road to the town of Semiro had turned the formerly arduous, dus bumpy drive into a pleasant one. North Semirom, we made our way along a na row dirt track farther into the mountains

Up against a mountainside, just where used to be, was the black goat-hair tent Borzu Qermezi. The former tribal hea man was leaning on a cane and peering o at the approaching vehicle. I was ove joyed to see him, for I had heard thir hand reports that he had been seriously i His wife, Falak, came down to greet with embraces and kisses and escorted back to the tent. Borzu held my hand a kissed my face, then leaned down a kissed Julia many times.

Two trucks hired to transport sheep a goats to market pulled up to the camp in flurry of dust. Their arrival gave Julia chance to become accustomed to the su roundings and enabled me to point out ce tain individuals to her while everyone ha tened to load the animals. Borzu called his son Mohammad Karim to collect lamb from the herd. Realizing his intent kept Julia from seeing him slit its throa Even though the lamb's sacrifice wa meant to honor our arrival (and to provid meat for a welcoming meal), it was not th first image I wanted her to have. Julia a I spent the rest of the day greeting a talking with people who came from nea by camps to see us. The weather becam cold as the sun set, and Julia sat close b me in the large tent.

After the celebratory dinner, Mohan mad Karim wanted to pitch the canvas te I had brought his family from the Unite States as a gift in 1977. I told him we ha a new one and began to unpack a bag tha the nomads thought impossibly small an too lightweight to hold a complete ten



During a visit to a neighboring tent, Julia holds the child of a Qashqa'i family.
Photographs by Lois Beck

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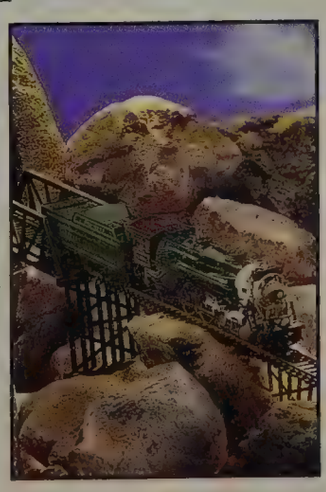


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poles and all. They needed several camels to carry each of their tents. Because the surrounding land was still muddy from the melting snow, Borzu insisted we pitch our tent inside his, where we would be warm and less buffeted by the wind. His daughter Fariba spread a ground cloth in a part of the tent usually reserved for guests and placed a finely woven carpet on top. There we set up our compact, brilliant turquoise nylon tent.

Julia was tired, so I was glad to unpack our sleeping bags and get her settled down to sleep. The night was so cold that water in the nomads' goatskin bags had partly frozen by morning, but Julia and I were toasty in our tent. She slept through the night and upon awakening in the morning was disappointed to learn that she had missed the tumult of the camp dogs chasing away wolves that had tried to attack the sheep.

After a tasty breakfast of freshly baked flatbread, new butter, and yogurt, Julia began to explore the camp. Mohammad Karim's children gave her a newborn kid, all black except for one white leg. When the frisky animal escaped, Julia tried to recover it but could not. When the children raced after it, she watched their technique, and by the end of the day she, too, could capture White Foot by anticipating the direction in which the kid would leap and then lunging after a rear leg.

Julia soon became a real help in camp, in ways that I had never been. I was not competent in the tasks that women of my age performed, but Julia was soon accomplishing practically all the tasks that children performed.

Two injured and ill sheep were tethered near a stone wall off to one side of the tent. On her own Julia took responsibility for their care. She went with Borzu's son Dariush to cut long grass growing by a mountain stream and fed it to the animals, and she often untangled the ropes from their legs. She would pat their heads and murmur encouraging words to them as she looked into their eyes.

Julia also worried about a baby goat with apparent neurological problems. Borzu's brother Jehangir kept the kid in an open wooden box, for it could not stand. When Julia carried the animal to its mother, it lay on the ground bleating with desperation, its legs splayed helplessly beneath it. Julia figured out how to hold both the kid and a teat so that the young animal could nurse. Jehangir showed her where to feel the kid's belly to know when it was adequately fed.

Julia learned to mimic exactly the "baaing" of the lambs and the kids, and even the nomads sometimes did not know if it was Julia teasing us from the rocky mountain slope behind the tent (where we could not see her) or an actual lamb or kid.

Julia quickly formed a special relationship with each person in Borzu's household. Because Borzu was still ill and could not easily stand or walk, Julia learned to anticipate his requests. She scattered chickens from the tent, and we gradually became used to abrupt, panicked squawkings as she disrupted yet another group of roosting chickens. One day Borzu spott a large lizard, considered by the nomads be polluting to the home, on the re screen in front of the tent. Julia came Borzu's assistance, grabbing his cane a chasing the lizard away.

At night Borzu did not sleep well a would often cry out, "Pain, pain!" Jul awakened by his cries, would call, "It's right, Borzu. Go back to sleep." Som times, when the pain was severe, he wou lament in his sleep, "Mother, moth where are you?" (His mother had di twenty years earlier.) As we travel through the summer pastures visiti other families, Julia would always ask r to tell Borzu's many brothers and siste about his pain and his calling for the mother. Julia worried about him ar would often sit close by him to play wi her toy sheep and goats and patiently sho him how to solve the puzzles she ha brought from home.

Several nights after our arrival, Jul asked me to identify the adolescent bo who sat slightly out of the circle of peop around the open fire. I replied that he w Ayad, Borzu's hired shepherd. She imm diately inquired, "But where is Falak shepherd?" I laughed and then translate for everyone, to their amusement. Fala Borzu's wife, joked, "You know, I real do deserve my own shepherd. I perform a the work around here" (which was in fa partly true, especially since Borzu ha been ill).

Borzu's sons who were still at hom Dariush and Bizhan, both in their earl twenties, became Julia's companion They often took her with them when the did their various chores, including the da they permanently separated the lamb from the ewes. She always helped bring i the lambs at night and settled them in the pen, and she worried when they bleate anxiously for their mothers.

Julia sensed the tension between Borz and Dariush. The two occasionally argue because Dariush wanted a salaried job i the city, while Borzu needed him to carr on pastoral tasks and to maintain the fam ily's nomadic life style.

Dariush and Bizhan taught Julia most o the Turkish words and phrases sh learned. On her own, she picked up the ex clamations and mild curses that people ut tered, and she would insert them in he conversation, which the others found en tertaining. "You offspring of an under sized donkey!" she would suddenly shou at a billy goat trying to eat wild herbs dry ing on a tray in the sun.



In a trick learned from other children, Julia sneaks a tasty curd ball from a drying mat.



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Fariba, Borzu's only daughter still at home (four older daughters were married and in their own tents in other camps), taught Julia how to churn yogurt and water to make butter, spin yarn from raw wool, fill goatskin water bags, gather wild herbs, and retrieve the donkeys. Shy about entering a tent filled with male visitors, Fariba would peek around the side, catch Julia's eye, and beckon to her. Julia would scamper out and be gone. She would come back later telling about her adventure and spouting new words and phrases. Fariba showed Julia how to roll out wet curds to dry in the sun. Julia had seen young children quietly sneak a ball of drying curd to eat, and one day I saw her doing the same thing, exactly the way that they did it, reaching up from underneath to the mat raised on poles.

We visited practically every family in these pastures. They were all people I had known before, and I was happy to see them again and renew ties. Many had lost sons in the Iraq–Iran war (1980–1988), and we wept together. I could not help remembering that many of these young men had been Julia's age when I first knew them, and I had watched them grow up.

I had expected that Julia might be shy when we went from tent to tent, meeting new people, but she was not. I would explain in advance how each person was related to Borzu by kinship and marriage. She became familiar with the arrangement of the tents and camps and learned about customary and proper behavior.

Julia became friends with Shapur, the teen-age son of Borzu's married daughter Zohreh. Whenever we visited their camp, Shapur took Julia with him as he did his chores. She collected feathers of all sorts and enlisted Shapur in this pursuit; he obliged by holding a live rooster still while she plucked out a particularly attractive feather. One day Shapur took Julia to show her a young wild bird he had found abandoned in a nest high on a mountain cliff. She returned with the bird, an unwieldy young falcon with a wingspan greater than the reach of her arms. Shapur nursed the falcon until it learned to fly and to hunt on its own.

On the afternoon we visited Jehangir's family, Julia showed him the fossil of a snail she had found. "Come with me," Jehangir promptly responded, "I know a place where there are many." And off they went, hand in hand, to a nearby hillto collect what he called "stone money flat, round fossils of mollusks and chiopods the size of large coins.

When we first arrived in May, the so Khalifeh, another former tribal headm took me aside to whisper that Khalifeh died many years before. When Julia a visited his camp several weeks late went to pay my respects to Khalifel climbed to the graveyard on a hillt tapped on Khalifeh's inscribed gravest with a nice round stone I had found on way, and told him how sorry I was no have seen him again. Then I saw Ju climbing up the hill. She too had foun stone on the way and came over to grave beside me. Without my saying word, she tapped on the gravestone a solemnly spoke, "Khalifeh, I wish I co have known you." I had not remembe telling Julia about the ritual. Perhaps saw someone else perform it.

Nights were always special for Ju Before going to sleep, we would take short walk to admire the changing sha of the moon, the bright planets, and multitude of stars. The high altitude a the absence of artificial lighting allowed to see a bright sky (despite the smoky ha drifting across the Persian Gulf to Ir from Kuwait's oil fields, set afire by Sa dam Hussein's army several months pre ously). Julia was often the first to set down to sleep, and she would listen as t family completed the work of the da Bizhan, last to get under the blanke would often play an audio cassette poignant Qashqa'i music. The tent final silent, the camp's dogs would begin work themselves into a frenzy of barki as they defended the camp and attack any stalking wolves, foxes, and hyena Julia laughed at the dogs' sudden transfo mation, for during the day they lay in stupor in the shade along a stone wall a would barely raise an eyelid as she passe by. Julia did not hear the sounds just b fore dawn—the crackle of the fire Fala was starting, Fariba rolling out brea dough and slapping the thin sheets on flat pan over another fire, Bizhan takin out the lambs eager to graze, and Borz clearing his head of the night's distresses

One night Julia woke me up to whispe that an animal was in our tent. She said sh thought it was nibbling the ball of drie curds she had hidden. Telling her it was dream, I patted her and told her to go bac to sleep. About an hour later, I felt some thing crawl up my back and into my hair. hastily brushed it off and then unsuccess



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fully tried by flashlight to find out what sort of creature it was.

The next morning, as people sat in a circle in the tent discussing their response to the imposition of an Islamic government, Julia shouted, "Mommy, crab, crab!" She knew she should not interrupt me, except in an emergency. There, close to all of us, was a large, black scorpion, its barbed tail poised, moving across the carpet (in crab fashion, as seen by a child). Fariba grabbed a metal pincer and dropped the scorpion into the fire. Everyone marveled that none of us had seen it and that Julia had rescued us from a possibly lethal, certainly painful sting. Perhaps it was the animal that had crawled up my back and into my hair.

Julia delighted in animal stories. One night Jehangir told of having seen that day a large snake devouring a smaller snake. Julia, who had begun to fall asleep in my arms, roused herself to ask me to tra his story and then questioned, "Head fi tail first?" We all laughed, for each of u formed a vague mental image of the sn feast but had not bothered to inquire the details. "Head first or tail first?" be a popular joke for the rest of our stay.

Shortly before our departure, Mohan Karim and several kinsmen set off to sh wild boar for us. I protested, but to no wild game was important in the Qas diet, and serving it was a way of honorin The hunters returned tired and irritate next day. "We rode to a place where dig for truffles," Mohammad Karin ported, "but we saw no sign of them. we hiked to the spring where tracks had spotted earlier. Thirty to forty boars drunk there but were gone."

"But with boars prancing about a spring," Julia responded, "and with so n hoof marks, how could you possibly k



"It obviously was in the path of a migrating tribe from the north."

number?" and she demonstrated with
hands and fingers the prancing of
ofs. We all laughed. Mohammad Karim
ologized for not being able to present
with a pair of tusks but promised to
e some for our next visit.
Just before we left, we visited the near-
tribal school. At first Julia was puzzled,
l then I realized she had expected some-
ng similar to her own school at home.
there, on a barren slope, was a small,
nd, open-sided canvas tent, two black-
rds, a rusty can of chalk pieces, a bat-
ed folding chair for the teacher (Borzu's
hew), and a tattered and faded Iranian
flapping from a pole. The children
ried their own few books back and
h every day. Julia asked, "But where
the 'learning areas'?" (as found at her
school). Then she gazed at the moun-
s around us and laughed at the irrele-
ce of her question.
On our way back to Borzu's tent, we
rted a small footbridge that had just
n built over a mountain stream. Fresh,
ist cement covered the top. Suddenly
a was walking across it. I asked her
at she thought she was doing. She
lied, "I want to leave footprints so that
ple will remember that I was here."
er that day I told people what she had
e, so they would look for her small
tprints in the hardened cement.
Bizhan offered to drive us to the town of
nirom so we could catch a ride back to
provincial capital of Shiraz. I packed
riedly, while Julia sat stunned by the
den departure. Everyone was in tears
en we kissed goodbye. At the outskirts
Semirom, Bizhan began to drive ex-
dingly slowly. I could not understand it
watched him out of the corner of my
. Julia sobbed, "Bizhan wants us to
s our ride, so that we won't have to
ve." She was right.
After we had left Semirom and were
veling along the road to Shiraz, we saw
ny tents of other groups of Qashqa'i
nads. "See that herd? They haven't sold
ir year-old lambs yet," Julia exclaimed.
ook! I bet Borzu wishes he still owned
nels like those. It's so dry here. I won-
how far the women have to go for
er. The people over there have only
vas tents, no goat-hair ones; they must
gypsies." Julia was right on these
nts, too.

*s Beck teaches anthropology at Wash-
ton University in Saint Louis. Her lat-
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Modified Grandeur

A crumbling pedestal supports our arrogant views of life

by Stephen Jay Gould

This is an essay about adjectives.

In an old theatrical story, W. S. Gilbert was leading a rehearsal for the première of his most famous collaboration with A. S. Sullivan, *The Mikado.* At one point, Nanki-Poo learns that his beloved Yum-Yum is about to marry her guardian, Ko-Ko. Searching for a straw of light, he asks: "But you do not love him?" "Alas, no!" she replies. On hearing this sliver of mitigation, Nanki-Poo exclaims "Rapture!"—or so Gilbert originally wrote. But at the rehearsal, Nanki-Poo stated his line too forcefully, given the limited comfort provided by Yum-Yum, and Gilbert shouted down from the balcony: "Modified rapture." The poor tenor, not grasping that Gilbert had only meant to correct his tone, and thinking instead that he had flubbed his line, exclaimed, "Modified rapture" at the reprise. This unintended correction elicited a good laugh, and so the line has remained ever since. If something so unvarnished as rapture must often be modified, let me pose a question in a similar vein: how shall we modify grandeur?

I asked myself this question in pondering the array of deep issues embedded within the most famous paragraph of our biological literature—the closing lines of Darwin's *Origin of Species.* Rarely have so few words raised so many hackles and fomented so much discussion. I quote from the definitive sixth and last edition of 1872:

> There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved.

Two features of this paragraph have been batted back and forth about the literature of the history of science (including a good deal of circulation through these columns). First, why did Darwin use theistic language here and only here, when he was at least agnostic in personal persuasion, and certainly believed (in any case) that worldly phenomena must receive naturalistic explanations? (The first edition uses the word "Creator" seven times, always in negative comparison to illustrate the superiority of evolutionary explanations.) We will never know the answer for sure, but one fact speaks volumes: the phrase "by the Creator" was interpolated by Darwin into later editions; the original passage, as published in 1859, read: "...having been originally breathed into a few forms or into one..." I rather suspect that simple diplomacy can best explain this dubious addition.

Second, why does "evolved," the very last word of the book, appear nowhere else in the *Origin of Species* (Darwin calls the process—later to be named "evolution"—"descent with modification")? I believe that Darwin shunned this word because he recognized that natural selection, his theory of evolutionary mechanisms, contained no postulate about progress as a necessary feature of organic history—and, in vernacular English at the time, the word "evolution" meant progress (literally, unfolding according to a preset plan).

But I want to focus on a third feature of this closing statement—its opening words. Why does an evolutionary outlook ("this view of life") imply "grandeur," and of what does this grandeur consist? Why does Darwin use the word here at all, and for the only time in the entire book? I started to ruminate about this issue because, by chance, I recently came upon another reference to "grandeur" from the generation before Darwin, and in a g work of exactly opposite import. This me to consider the chronology grandeur—in particular its apparent duction, as illustrated by nouns and ad tives, through three stages: the creatio world just before the *Origin of Spec* Darwin's evolutionary reformulation, our modern view of life's history. We that we have gained greatly in factual theoretical understanding through th three stages; but if we have lost a degre grandeur for each step of knowle gained, then we must fear Faust's barg "For what shall it profit a man, if he s gain the whole world, and lose his o soul?" (Mark 8:36.)

Stage One: Pre-Darwinian Grandeu was recently invited by the American ciety for Surgery of the Hand to pres the inaugural lecture at their annual me ing in Phoenix. I was given a free rein topics, and could have chosen anythi from evolutionary manifestoes to creati ist manipulations. But a Darwinian bio gist with a sense of history could move only one direction: toward his booksh and a copy of the last great summary of distinctively English brand of creationi known as "natural theology"—the vi that not only God's existence, but also attributes of power and goodness, may inferred from the character of his creati particularly the good design of organis and the harmony of ecosystems. T work, published in 1833 by the celebrat British anatomist and physician Charles Bell, is entitled: *The Hand: Mechanism and Vital Endowments Evincing Design.*

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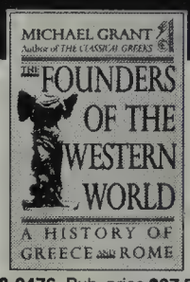
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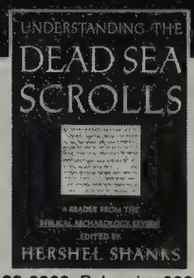
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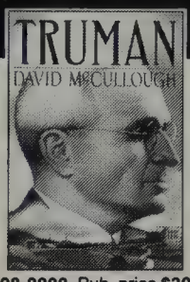
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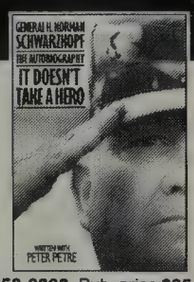
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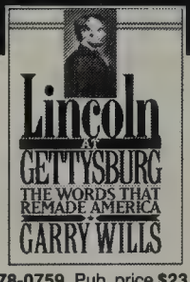
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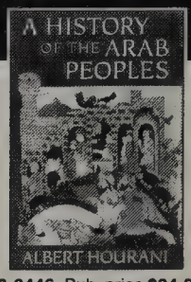
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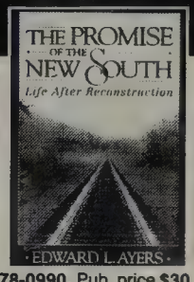
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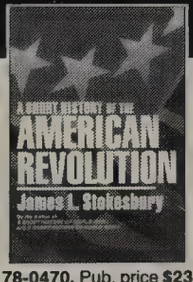
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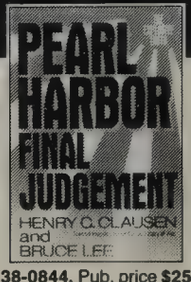
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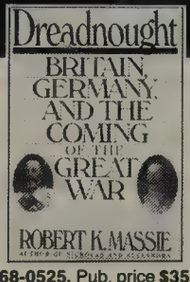
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the power, wisdom, and goodness of God, as manifested in the Creation." The enticements were virtually irresistible, for the nominating committee included the President of the Royal Society (Britain's leading scientific organization) and the Archbishop of Canterbury, while the good earl had specified "moreover, that the profits arising from the sale of the works so published should be paid to the authors of the works."

The resulting eight volumes, collectively called the *Bridgewater Treatises* (at least by their friends, for doubters usually referred to them as the "Bilgewater Treatises"), therefore featured a collection of famous authors, including William Whewell, Britain's leading philosopher of science; William Buckland, Oxford University's first professor of geology; and Peter Mark Roget, of thesaurus fame. The distinguished nominators selected Sir Charles Bell for one of the few topics that the earl of Bridgewater had specifically designated for treatment in his will—"the construction of the hand of man."

The Bridgewater Treatises represent the last major statement of natural theology, a distinctively English tradition in both religion and natural history, with roots in John Ray's late seventeenth-century writings, a trunk in William Paley's *Natural Theology* of 1802, and a last set of branches in the earl's posthumous literary legacies. A great lumberjack named Charles Darwin visited this particular glade a few years later.

As one would expect from title and context, Bell's volume focuses on the human hand as an ultimate expression of divine wisdom in creative design:

It is in the human hand that we have the consummation of all perfection as an instrument. This, we perceive, consists in its power, which is a combination of strength with variety and extent of motion; we see it in the forms, relations, and sensibility of the fingers and thumb; in the provisions for holding, pulling, spinning, weaving, and constructing; properties which may be found in other animals, but which are combined to form this more perfect instrument.

But Bell also extended his argument further to consider the entire pattern of life's history through geological time—and he promptly ran into a difficulty that confronted all natural theologians. The fossil record seemed to indicate an improvement in complexity of design through time—invertebrates only in the oldest rocks, followed by fishes, reptiles, mammals, and a creation of man so recent (for no human fossils were then known) that his remains are unrecorded in our geological strata. Superficially, this pattern looks good for God—a series of creations and extinctions, with mounting excellence in each new try as the eventual entry of man draws nigh (I am purposely using the justly abandoned, gender-biased language invoked from time nearly immemorial through Bell to just a few years back). But a natural theologian, committed to the proposition that God creates in perfection, must balk—for God can always make just right; so why should he have created something less than perfect at first? Surely he doesn't need to practice, and could have fashioned absolute organic optimality a millimicrosecond after creating the universe itself.

Bell resolved this paradox (following his colleague Buckland's lead in the geological treatise of the Bridgewater seri by arguing that each successive creatio both perfect for its own time and more cellent in design than the previous and tirpated version. Perfect can only me ideally adapted to local environmen Suppose then that the environment came tougher and more diverse throu time—a general result of the earth's co ing in Buckland's scheme. The langu low-lying topographies of the early ea were made for simple creatures, and suited to exalted human capacities. B wrote:

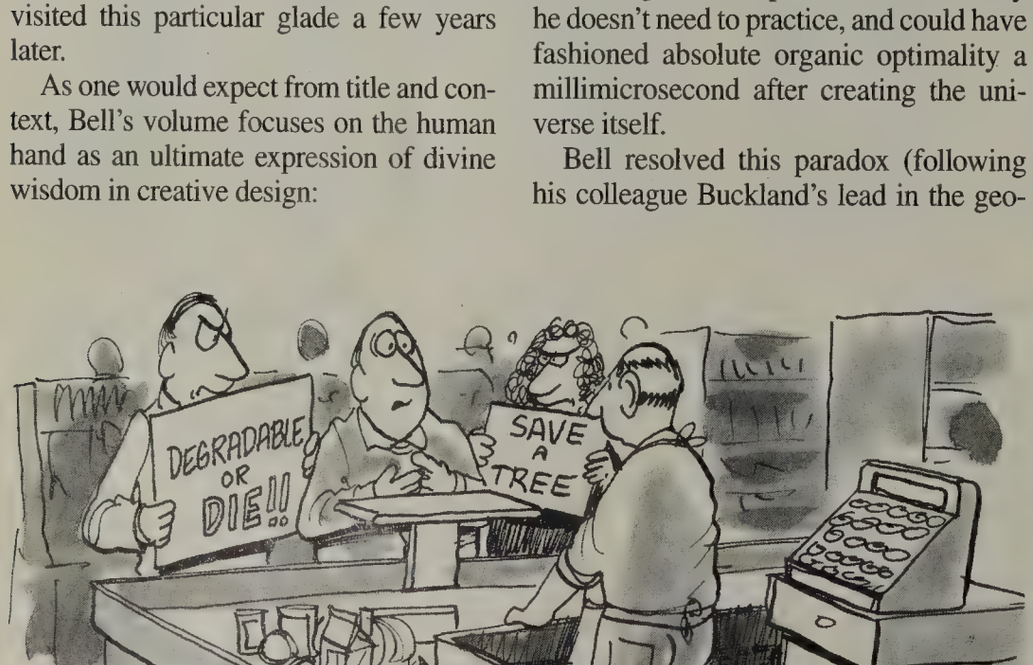
These animals inhabited shallow seas, a estuaries, or great inland lakes…the surfa of the earth did not rise up in peaks a mountains.… It was flat, slimy, and cove with a loaded and foggy atmosphere. Th is, indeed, every reason to believe that classes mammalia and birds were not th created; and that if man had been placed this condition of the earth, there must ha been around him a state of things unsuit to his constitution, and not calculated to forth his capacities.

The simple creatures of these times we perfect for their primitive surroundin "No fault is to be found with the constru tion of these instruments; they are suited their offices, and no bone is superfluous, misplaced, or imperfect." The history life is, therefore, simultaneously a tale perpetual perfection and continuous crease in complexity of design.

Bell, in summarizing this noble visi waxed poetic and spoke about grandeur in fact, grandeur beyond grandeur, as illu trated by a well-chosen adjective. Whe discovered this passage, and compared adjectival embellishment with Darwi unornamented grandeur, the disturbi germ of this essay (later resolved, at lea personally) took root in my own gla Bell wrote:

There is extreme grandeur in the thought an anticipating or prospective intelligenc in reflecting that what was finally acco plished in man, was begun in times incalc lably remote, and antecedent to the gre revolutions which the earth's surface h undergone.… If we seek to discover the lations of things, how sublime is the relati established between that state of the earth surface, which has resulted from a long su cession of revolutions, and the final con tion of its inhabitants as created in acc dance with these changes?

Let us review the components of th scheme that would lead a man like Bell call its grandeur extreme—or at least wo drously suited to human arrogance: a mals are always perfectly designed f

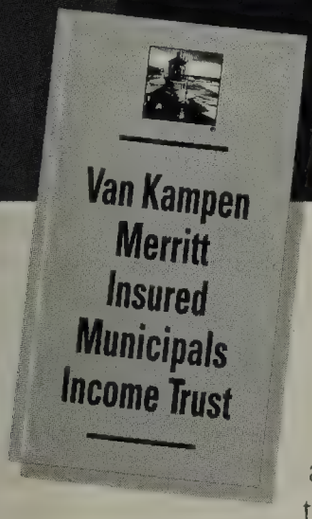


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their immediate world; yet life's history also displays a linear trend to increasing excellence culminating in the recent arrival of man. In fact, man is foreshadowed from the very beginning, and his eventual origin is the pith and purpose of the entire panoply. What could be more grand, more extremely grand, than such a purposeful drama that puts *Homo sapiens* both in perpetual center stage and atop the ultimate peak at the end of the last act?

Stage Two: Darwin the lumberjack lops off an adjective. I cited Darwin's statement about unvarnished grandeur earlier in this essay. Of what does this grandeur consist in our scientific culture's first fully defensible theory of evolution? Darwin gives us the answer in a brilliant comparison later in his final paragraph. He contrasts planetary motion in the Newtonian cosmology with directionality in the history of life. Planetary history, at base, is endless repetition to nowhere—essential, no doubt, to our planet's continued existence, but not very interesting in lacking any directional component: "whilst this planet has gone cycling on according to the fixed law of gravity…" Darwin writes. But life's history, by explicit contrast, is an endlessly ramifying tree, growing upward toward the light—and such motion constitutes grandeur: "from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved." The "grandeur in this view of life" lies squarely in the contrast of cyclicity on a physical home with directionality of the biological inhabitants.

But Darwin has taken us down a peg, at least in terms of our standard cultural hopes and deep-seated arrogances. Bell's progressive creationism gave us a foreordained history of life, always perfect but moving upward toward an inevitable apotheosis in the origin of *Homo sapiens.* Darwin still sees expansion from original simplicity (the ever-ramifying tree of life in his metaphor), but specific outcomes are no longer ordained, and increase in complexity is only a broad trend, not a grand highway toward life's primary goal. Does this change—a demotion in psychological comfort at least—explain why Bell could call his grandeur "extreme," while Darwin applied no adjective at all?

Stage Three: Wonderful perhaps, but is it grand? Darwin remained deeply ambivalent on the crucial issue of progress in life's history. He understood that the "bare-bones mechanics" of natural selection included no such principle, and he was enough of a philosophical radical to revel in the extensive implications of such a discomforting view. (Natural selection only produces adaptation to changing local environments, not global progress. A woolly mammoth is well-adapted glacial climates, but cannot be called generally improved elephant.)

But Darwin was also a truly emine Victorian—a wealthy, white male co mitted to (and greatly benefiting from) society that had, perhaps more than a other in human history, made progress t centerpiece of its credo. How could D win jettison progress altogether in this a of industrial might, military triumph, a colonial expansion? Darwin therefo placed a modified form of progress ba into his view of life through a suppleme tary argument about ecology and compe tion. The "struggle for existence," Darw argued, proceeds in two basic mode against the physical environment, or w other members of a population in a bat for scarce resources. Darwin writes: "Tw canine animals in a time of dearth, may truly said to struggle with each oth which shall get food and live. But a pla on the edge of a desert is said to strugg for life against the drought."

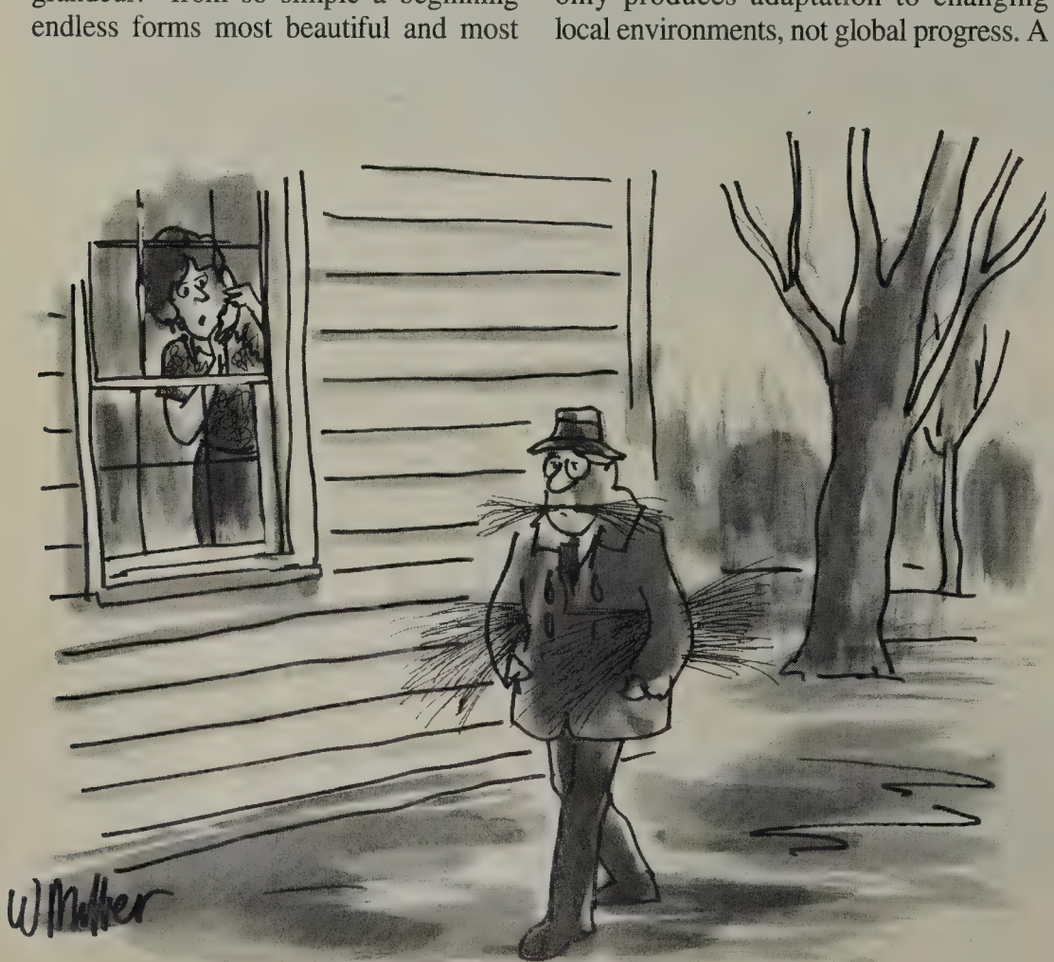
Struggle against the physical enviro ment yields no vector of progress, for l merely tracks a fluctuating and nondire tional history of climate and topograph But true battle against one's peers (t "gladiatorial view" in Huxley's term might validate a trend toward improv ment, since such global features as mo stamina, increased intelligence, a greater complexity of weaponry mig now be favored. Therefore, if this organ mode of competition tends to be more fr quent than the inorganic style, life mig show an overall tendency toward progres

Darwin then argued that organic co petition does predominate because mo habitats are chock-full of species, and ne forms can insert themselves only by pus ing a competitor out in overt struggle. weakly directional progress therefo characterizes life's history. Darwin write

The inhabitants of each successive period the world's history have beaten their pred cessors in the race for life, and are, in so fa higher in the scale of nature; and this m account for that vague yet ill-defined sen ment, felt by many paleontologists, that o ganization on the whole has progressed.

Is it any wonder, then, that Darwi grandeur is an adjective less intense tha Bell's? Darwin still gives us a form progress—his tree of life does grow u ward—but what a paltry thing (in conve tional terms) compared with Bell's versio of a straight and narrow road to huma transcendence.

And where are we today, when mar



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paleontologists espouse a view of life with even less emphasis on progress (if not an outright denial of the concept in any conventional sense), and increasing sensitivity to the many elements of randomness and contingency that make any particular pathway—including the route to *Homo sapiens*—utterly unpredictable and unlikely ever to arise again if the tape of life could be replayed from scratch? Bell exalted humans as the top rung of an inevitable ladder. Darwin perceived us as a branch on a tree, but still as a topmost shoot representing a predictable direction of growth. Many paleontologists, myself included, now view *Homo sapiens* as a tiny and unpredictable twig on a richly ramifying tree of life—a happy accident of the last geological moment, unlikely ever to appear again if we could regrow the tree from seed.

If Darwin could only muster an unmodified grandeur for his weak version of progress, what can we offer today? The next step down from no adjective is loss of the noun as well—that is, no grandeur at all. Indeed, I recently wrote a book on this revised concept of life's history. I found the new view intellectually thrilling and utterly fascinating as a challenge to our social traditions and psychological hopes. I called the book *Wonderful Life,* but I don't think that I ever spoke of the fossil record in terms of grandeur.

How shall we react to this loss of traditional comfort and exaltation in considering the paths of life's history—this demotion of grandeur in three stages from extreme to unvarnished to absent? Must an increase in knowledge and understanding always carry the price of psychological sadness?

We might just react stoically and recall J. S. Mill's dictum that it is better to be Socrates dissatisfied than a pig satisfied. Or we might look favorably upon the good lesson that comes with a cold bath, and remember Sigmund Freud's famous observation that each revolution in the history of science greatly augments our power and understanding, but also dislodges us from a pedestal of previous cosmic arrogance. We first located ourselves at the center of a limited universe, but Copernicus and Galileo taught us that we inhabit a peripheral speck in a cosmos "of a magnitude scarcely conceivable." We then imagined that God had created us in his own image on this little speck, until Darwin "relegated us to descent from an animal world." (In one of the least modest statements of intellectual history, Freud then says that at least we believed we had rational minds until he discovered the unconscious.)

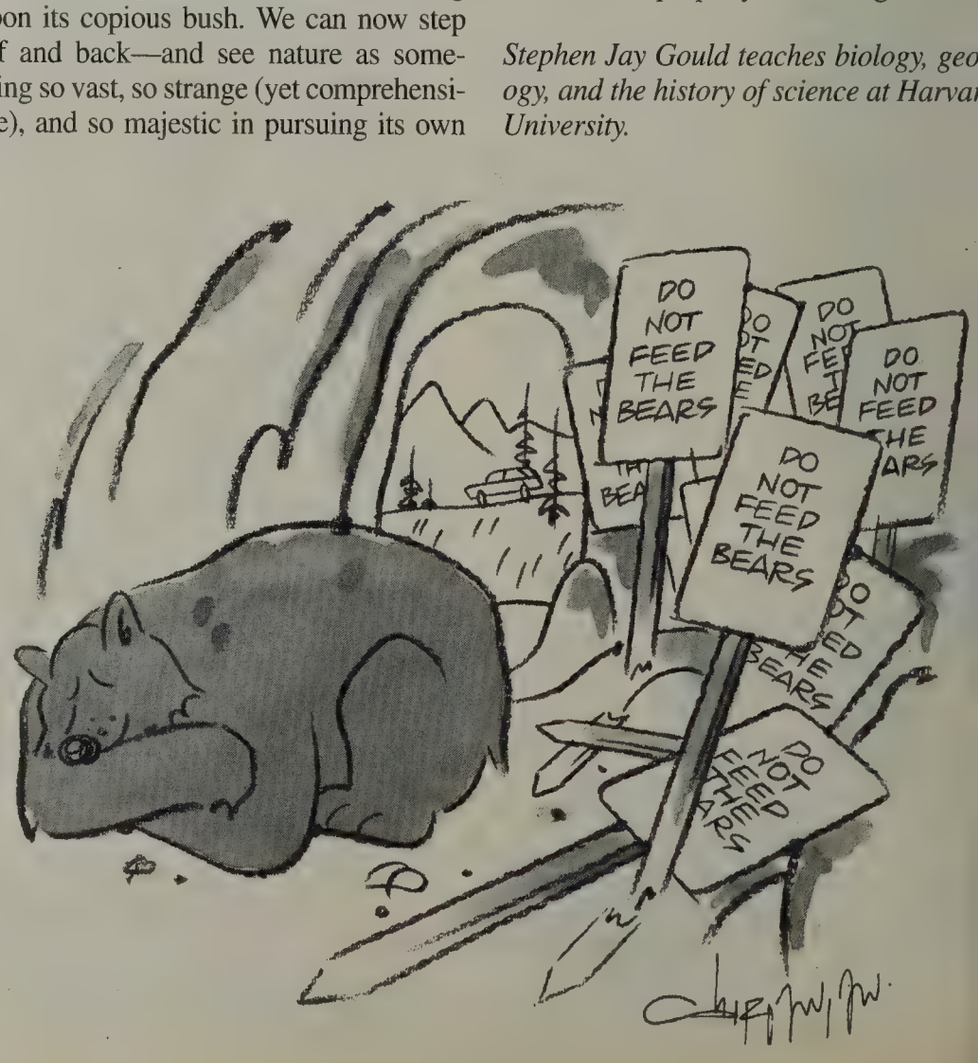
I want to propose another approach, for I yearn to reestablish an appropriate notion of grandeur. Previous concepts have doled out grandeur to life according to its degree of conformity with *our* hopes and arrogances—most to Bell for placing us on a foreordained and inevitable top; less to Darwin for retaining a progressive directionality to contrast with planetary cycling; none to a modern view that demotes us to twigdom on a tree of life more strange and fascinating than ever.

As its primary definition of grandeur, the Oxford English Dictionary offers: "transcendent greatness or nobility of intrinsic character." Does not this definition permit, nay compel, us to imbue life's history with a notion of grandeur even firmer than Bell's? We have erred in the past by assessing grandeur largely in terms of how nature depicts our origin and our status. But this ruling dictionary tells us that grandeur rests upon "intrinsic character"—and nature can therefore only be grand in its own terms. For me then—and I will admit that grandeur must remain a largely personal and aesthetic concept—the modern view is grandest of all, for we have finally freed nature from primary judgment for placement of one little twig upon its copious bush. We can now step off and back—and see nature as something so vast, so strange (yet comprehensible), and so majestic in pursuing its own ways without human interference, th grandeur becomes the best word of all f expressing our interest, and our respect.

But we surely need an adjective, for th grandeur is greater even than Bell's. I hav played with many alternatives and rema open to suggestion. I considered "ineff ble" or "unspeakable," but then I couldn write any more essays. As a fan of wor with both vernacular and rarefied mea ings, I toyed with "terrific," but finally d murred in recalling the older and literal d finition of "terrifying"—for nature may b strange, but is neither scary nor evil.

My current favorite is "awesom grandeur"—a nice mixture of the vernac lar kiddie-culture sense of "terrific" or "r ally cool, man," with the older and mo sublime version captured by the Oxfo English Dictionary in tracing an appropr ate historical path from theological drea to reverent fascination: "From its use i reference to the Divine Being this passe gradually into: Dread mingled with vene ation, reverential or respectful fear; reve ence in the presence of supreme authorit moral greatness or sublimity." And finall to the next and best sense: "The feeling o solemn and reverential wonder, tinge with latent fear, inspired by what is terr bly sublime and majestic in nature." I other words, properly modified grandeur.

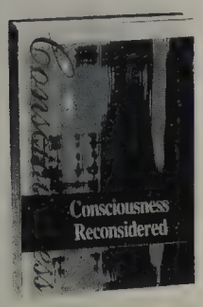
Stephen Jay Gould teaches biology, geo ogy, and the history of science at Harvar University.



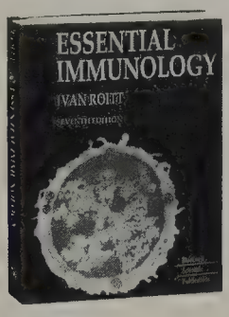
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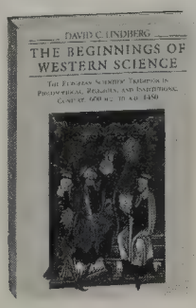
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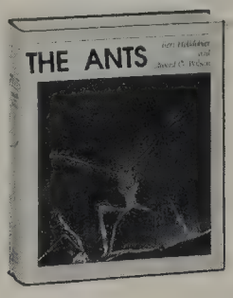
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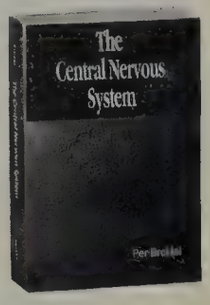
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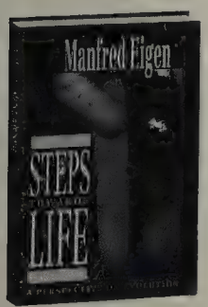
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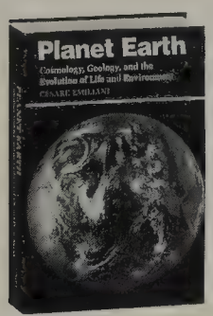
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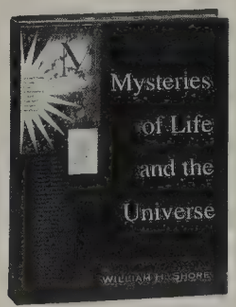
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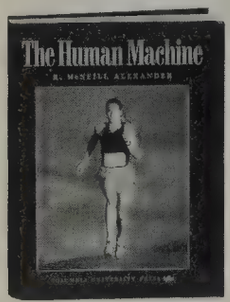
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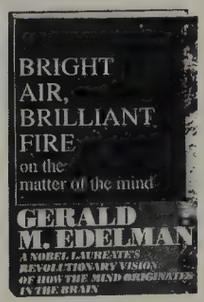
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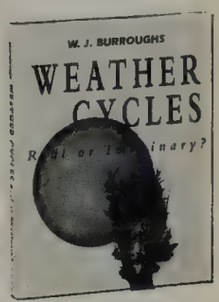
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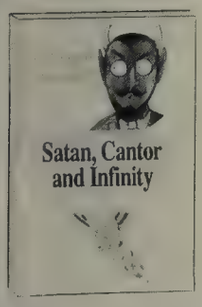
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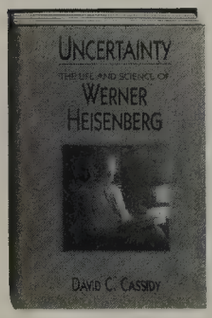
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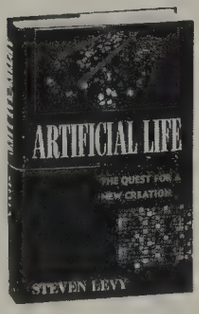
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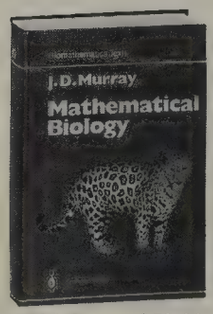
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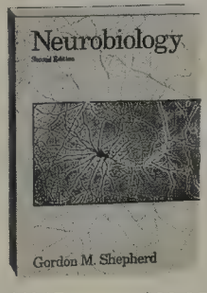
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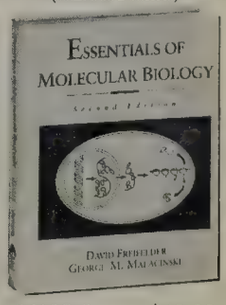
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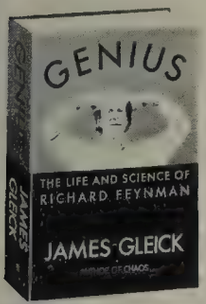
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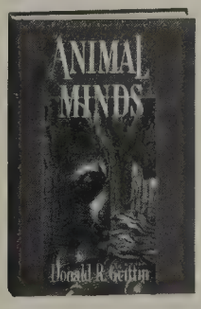
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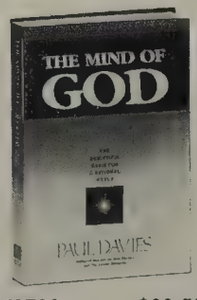
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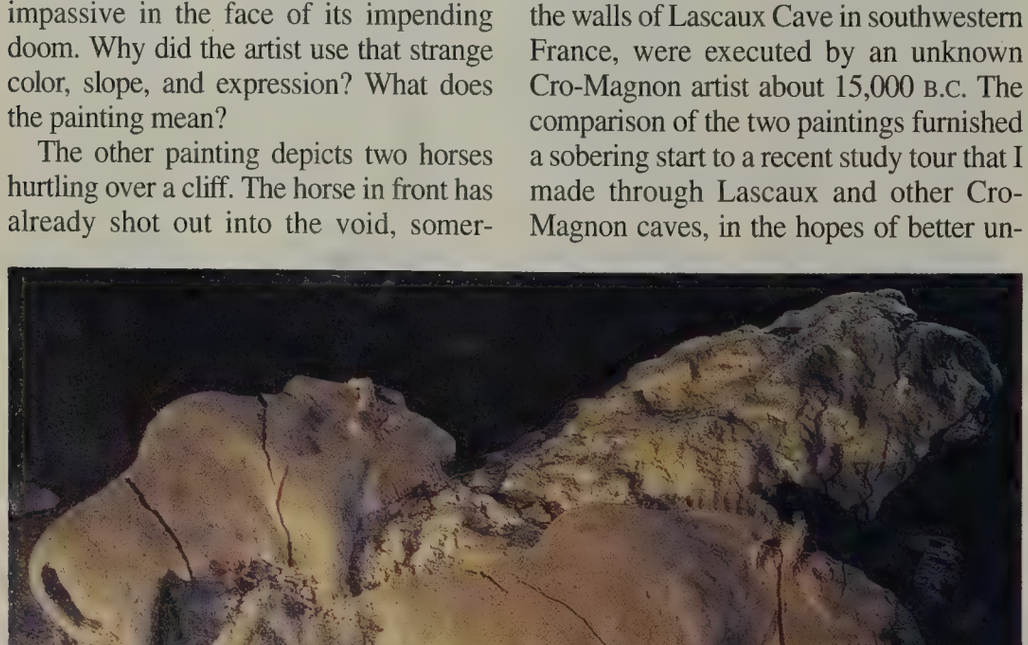
As we achieve new understanding of Cro-Magnon cave paintings, we may in turn gain new insights into our future

by Jared Diamond

On two walls in southwestern Europe, a few hundred miles apart, stand two famous, gripping, and disturbing paintings of animals on the verge of death. One depicts a drowning dog, with only its head showing above the water's surface. The water is painted a rich brown rather than blue, and its surface isn't horizontal but slopes upward from left to right across the painting, growing into a pillar of water that dwarfs the dog. Directly over the dog towers yet another column, a void of golden air. The dog's expression seems strangely impassive in the face of its impending doom. Why did the artist use that strange color, slope, and expression? What does the painting mean?

The other painting depicts two horses hurtling over a cliff. The horse in front has already shot out into the void, somersaulted upside down, and is plunging with its extended legs pawing the air. The horse behind is about to go over the cliff in full gallop; one of its forelegs has just cleared the edge as it leaps toward its companion. The literal meaning of the scene is vivid enough. But what did the artist mean, depicting the horses at this moment?

Drowning Dog, mounted on the walls of Madrid's Prado Museum, is one of the famous Black Paintings executed by the Spanish artist Francisco Josè de Goya about 1820. The falling horses, painted on the walls of Lascaux Cave in southwestern France, were executed by an unknown Cro-Magnon artist about 15,000 B.C. The comparison of the two paintings furnished a sobering start to a recent study tour that I made through Lascaux and other Cro-Magnon caves, in the hopes of better understanding those ancient artists. We kno Goya's name. Detailed biographies of h life are available, many of us still speak h language, his culture lives on today, an we know the circumstances under whic



Clay bisons in Tuc d'Audoubert Cave, France
Robert Bègouën

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The new Hall of Human Biology and Evo lution will open on April 23 at the Amer can Museum of Natural History. In con junction with this event, the April an May issues of *Natural History* will con tain special sections on human evolutio and paleolithic art.

he created his Black Paintings. Despite-a that, we still cannot plumb Goya' thoughts: his *Drowning Dog* remains in scrutable. If I could not understand Goya' painting, how could I hope to understan paintings by unknown artists, speaking a unknown language in the remote past, an practicing a vanished life style?

My interest in visiting Cro-Magno caves grew out of my recent book, *Th Third Chimpanzee,* in which I had tried t find animal precursors for our apparentl uniquely human traits. That effort shoul be possible because our genes are still 98. percent identical with chimp genes, an because our behavior was largely apelik as recently as a hundred thousand year ago. I had no difficulty tracing murder an genocide by humans directly to the sam practices in chimps, with little differenc except for our more efficient weapons While human language, sexuality, and too use may appear to be unique, clear precur sors exist in chimps.

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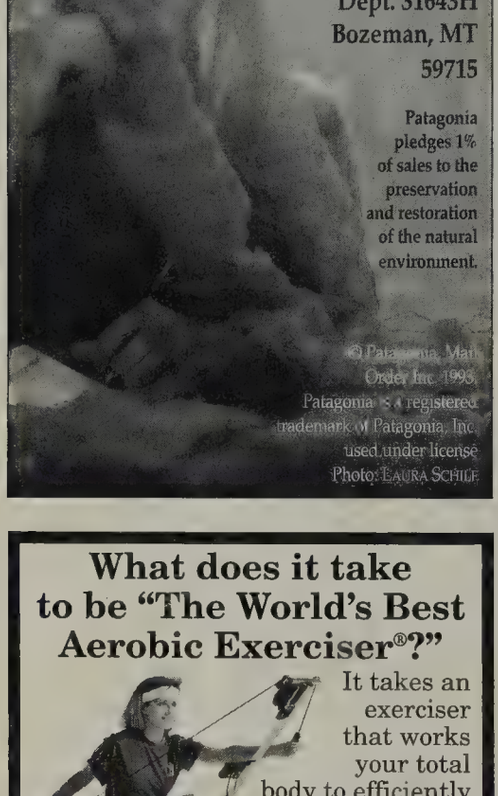
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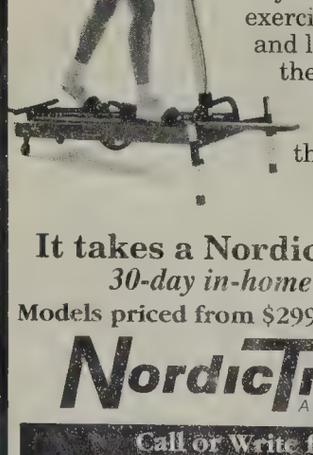
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The most puzzling human product for me was art, which suddenly burgeoned about 30,000 years ago at the time of our "great leap forward," when other signs of human inventiveness also appeared rather suddenly in the archeological record. I thought that I could tentatively identify some remote forerunners of human art, such as bower decoration by bowerbirds. Nevertheless, human art is so distinctive that I had to wonder whether it really is an expansion of those animal precedents, or something basically new and unprecedented.

Most of human prehistory has left behind no convincing trace of art at all. Perhaps our remote ancestors painted their bodies, but if that was the first art, it wouldn't have survived for us to know about. The first preserved art developed more or less simultaneously in Europe, Africa, and Australia, with some further recent discoveries of old art in Asia and the Americas as well. That dawn of art was also the flowering of human inventiveness, reflected in the rapid development of sewn clothing, complex houses, multipiece specialized tools, and many other inventions.

Early art itself assumed many forms, ranging from wood- and bone-carving, engraving, bas relief, and three-dimensional sculpture to painting and music. Best known to modern Europeans are the cave paintings of so-called Cro-Magnon people in France and Spain, living in the era termed the Upper Paleolithic (from about 40,000 to 10,000 years ago). Those cave paintings rivet our attention not only because they include great art by any stan dard but also because of the obvious ques tions that flash out. What sort of peopl were those painters? What motivate them to paint and why did they do it i caves? How did their style change wit time? Was Cro-Magnon art a brief fad or long tradition? Why did it end so abruptl about 10,000 years ago?

Curiosity about all those questions le me to jump at an opportunity to visit Las caux and Altamira, the Sistine Chapels o Cro-Magnon art, as well as other nearb caves. I owe a large debt to Margaret Cor key, Laurence Beasley, Count Robert Bè gouën, Jean Clottes, and Henry Hopkin for their patience with all my questions.

As a serious cave explorer during m student years, my first reaction was appre ciation for the Cro-Magnon speleologica accomplishments. In multilevel caves such as Tuc d'Audoubert and Gargas, th scattered artifacts prove that Cro-Magno people reached all accessible galleries o several levels. They explored many mile of passages in long caves like Rouffigna and Niaux and were stopped only b sumps (passages flooded to the roof) which also stopped twentieth-century spe lunkers until the recent development o cave-diving gear. Why did they explor the caves? The answer seems obviou upon entering. The long, high, silent blac corridors of Gargas and Rouffignac fill th viewer with awe, while the riot of colore stalactites and stalagmites in Cougna stuns us with its beauty. Probably Cro Magnon spelunkers explored for the sam reasons. In that respect, as in so many oth

's, they were modern humans, whereas eir predecessors, the Neanderthals—like odern apes—rarely penetrated the caves eyond the zone of sunlight.

We think of cave art as made by "cave-en," a term that immediately evokes im-ges of hairy brutes, partly draped in ani-al furs but with at least one shoulder are, clubbing instead of wooing their ides, and grunting over a fire. Even the formational film shown to tourists at the cavated Cro-Magnon site of Abri Pa-ud perpetuates this nonsense.

In fact, the Cro-Magnons lived far from ves, as well as within them; we think of em as cavemen only because the gar-age they left in caves is more likely to ave been preserved than other artifacts. rom their garbage, burials, and art, we ow that they had needles, buttons, sewn othing, and parkas and were probably as armly dressed as modern Eskimos. Rela-onships among existing languages today iggest that fully developed languages ad already arisen tens of thousands of ears ago; the Cro-Magnons may have oken a language ancestral to a modern e. Their caves are still littered with their one lamps, fuel caches, paving stones, ints, crayons, palettes, and even their ces and food scraps. They marked caves ke Niaux with trail signs termed clavi-rms, which warned Cro-Magnon tour-ts to stay on the right-hand side of wide assages, to look for art in concealed ches, and to avoid bumping their heads places with low ceilings. Their foot-ints are still on the cave floor, their hand-ints and marks of their scaffolding still the cave walls. While visiting some of e sites, I had the vivid sense that the tists had walked off the job only yester-ay.

That same sense was apparent in the re-ctions of some Eskimo hunter/artists sent the Canadian government earlier this ear to visit the French cave of Tuc d'Au-bubert. Its owner, Count Robert Bè-bouën, explained to the visitors that car-bon-14 dating demonstrated that the cave ad been occupied more than 10,000 years go. Whatever impression that explana-on made faded as the visitors saw the otprints, lamps, and other obvious signs people with a familiar life style. When e Eskimos came to the first Cro-Magnon engravings, they praised them to Bègouën, onvinced that he himself was the artist. gain he explained about carbon-14 dat-g, and they went on through the cave ntil they reached the last chamber, with s spectacularly realistic clay models of

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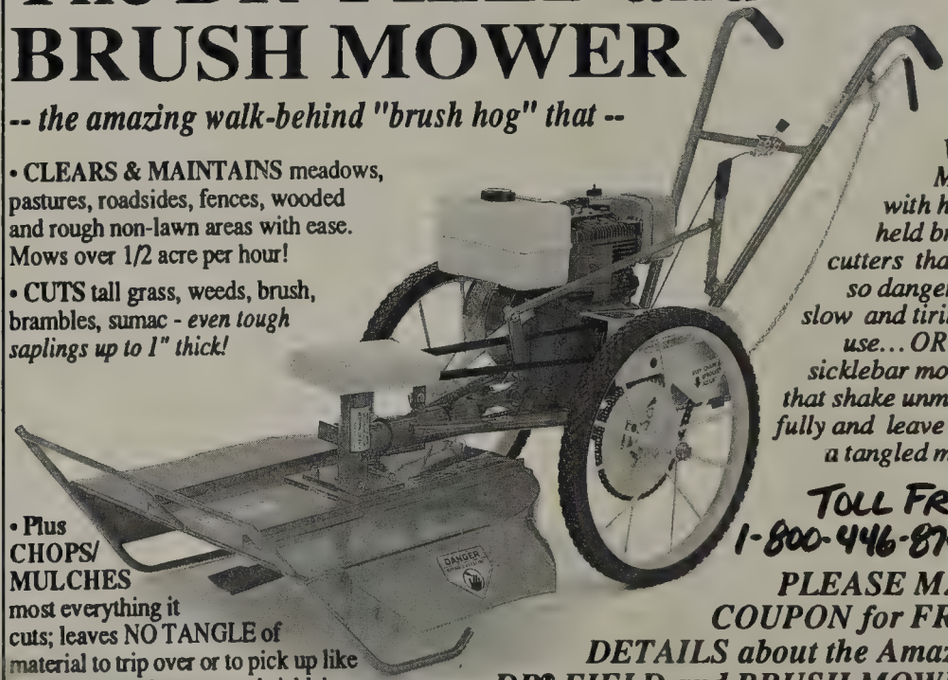
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bison. At that point, the visitors enthusiastically complimented Bègouën on "his" beautiful sculptures.

I relate this story not to poke fun at the visitors but because their perceptions were correct. If it were not for the carbon-14 dates, the caves would indeed convince us that the human artifacts are modern, left behind by people not too dissimilar in life style to modern Eskimo hunter/artists. Many of the nineteenth-century Europeans who discovered Cro-Magnon cave art before the days of carbon-14 dating believed that it was recent. Depictions of animals in Rouffignac Cave have been known since at least A.D. 1575, yet debate persists today as to whether they are Cro-Magnon engravings or just modern graffiti (because engravings cannot be radiocarbon dated).

Like modern art, Cro-Magnon art varies widely in quality, even within the same cave chamber. Some of it impresses us as great, some as amateurish. Professional artists visiting the caves with me pointed out the sophisticated techniques by which some Cro-Magnon artists succeeded in conveying a sense of scale, motion, and perspective. Exquisite pieces such as the clay bison and the carved wrestling ibex from Tuc d'Audoubert achieve their expressiveness with an economy of line and shape. Especially notable is the obviously intentional exploitation of irregular cave surfaces to transform some cave paintings into three-dimensional compositions. For example, when I knew the falling horses of Lascaux only from photographs, I had no inkling that the horse to the rear is painted on a wall with a ledge, so that it seems actually to be stepping over the ledge; the painting thereby becomes more terrifying. Similarly, the two famous reclining, curled-up bison of Altamira are painted on bulges in the ceiling that emphasize their central role in the painted bison herd.

Besides being great artists, Cro-Magnon painters were also keen biologists. Some animals are depicted with anatomically correct details as small as a bison's tear duct or a mammoth's anal operculum. Failing to understand or appreciate what good biologists Cro-Magnon artists were has led art historians into some embarrassing misinterpretations. For instance, on the ceiling of Altamira's Great Hall are painted twenty bison, some of them unmistakably females with udders, others males with details of the penis visible. Some art historians deny that the various animals depicted constitute a unified composition, and even that "primitiv people" were capable of planning a unifie composition. One well-known theory i terprets all Cro-Magnon art as symboli not naturalistic, and interprets the pairs animals in the Great Hall as represent tions of masculine/feminine dualism ar unrelated to other pairs.

But modern studies of the mating b havior of bison strongly suggest that th Great Hall depicts, with stunning acc racy, a herd of bison during their brief lat summer rut, the sole time of year whe adult male and female bison associa closely. Biological understanding can eve explain a scene of which art historian have been unable to make any sense: a d piction of a female bison mounting male! As farmers and animal behaviorist are aware, and as Aristotle described mo than 2,000 years ago, sexually receptiv cows and female bison often do mou bulls to arouse them if they are not qui ready to copulate. Thus, the Altami Great Hall may be neither a collection individual paintings that happen to sha the same ceiling nor a symbolic expre sion of male/female duality, but a unifie realistic composition by an artist or grou of artists familiar with bison habits.

Why do most of the larger cave pain ings depict animals, rather than people? simple explanation used to be accepte that the paintings were of the animal sp cies most often hunted. We now realiz that although the most frequently painte animals—horses and bison—were indee hunted, they account for a much high proportion of painted animals than of th hunter's bag. We know what Cro-Magno artists were eating because they ate lunc on their scaffolding and dropped the garbage—piles of animal bones—beneat them. Among large mammal species, th ones most frequently eaten were red dee reindeer, and ibex. As a joke among archa ologists goes, "The Cro-Magnons ha deer and ibex in their stomachs, but hors and bison on their minds." Their stomach were also full of unheroic small animal such as clams, ptarmigan, and salmon— which they did not paint.

I believe that these prejudices of Cro Magnon artists were as thoroughly mod ern as the trail signs that they sprinkle throughout their caves. In today's art, too the animals that we prefer to depict aren the ones that we most often eat, use, or en counter. If future archeologists sampl American gates and other decorative ob jects, the archeologists might be deceive into believing that lions and eagles wer

ar more familiar to us (and to Western rtists for the last 4,000 years) than squir-els or cows. In villages throughout New Guinea, village art regularly depicts croc-diles, hornbills, and sea eagles, rather han such frequently eaten species as pi-eons, pigs, and possums. Just imagine the Jnited States seal of state displaying a quirrel or a New Guinea house pole rowned by a carved pigeon!

Modern peoples are attracted to certain nimal species either because of the quali-es that they symbolize (the strength of a on, eagle, or crocodile) or because of heir striking anatomy (the hornbill's huge ill). Similarly, Cro-Magnon artists may ave preferred painting speedy horses and owerful bison to depicting the slimy little lams that filled their stomachs.

Why did Cro-Magnons create cave art t all? Archeologists used to debate uni-ary functional interpretations: that the aintings represented mindless copies of ature by savage people, *or* magical rites o ensure success at hunting, *or* parapher-alia for impressing naïve teen-agers at nitiation ceremonies, *or* depictions of nyths, and so on. Such unitary theories ell into disfavor as anthropologists began o ask contemporary aboriginal Aus-ralians and Bushmen why they create heir own rock art. The reasons turned out o be ones that any future art historian vould be very unlikely to deduce. The ame image—for example, a fish painted y aboriginal Australians—proves to have een painted for different reasons on dif-erent occasions. Some fish paintings erve to mark a tribal territory, others tell a tory ("I caught this big fish"), still others pring from the trances of shamans. It houldn't surprise us that the Cro-Magnons' motives may have been equally iverse, given all the other evidence for heir modern mentality. If you're disap-ointed to realize that Lascaux's falling orses may always remain as obscure to us s Goya's *Drowning Dog,* you've still dis-overed something far more important in he process: that Upper Paleolithic people vere already much more like us in their inds than in their technology.

Meanwhile, new scientific techniques re emerging that show promise of being ble to answer other intriguing questions bout early art. If we could date enough ro-Magnon paintings, for instance, we ould trace the development of humanity's rst art styles, and we could say whether ro-Magnon artists of France and Spain ight have been contemporaries within he same tradition.

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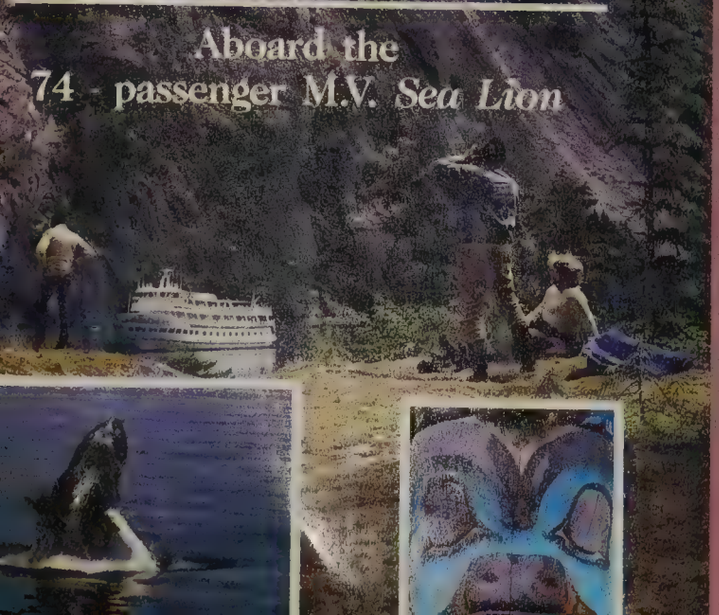
Until recently, the prospect of radiocarbon-dating the precious paintings themselves seemed out of reach, because too much would have to be scraped off and destroyed in the process. Instead, archeologists have tried to date the paintings by either of two methods. First, they dated human rubbish left in the caves—but the rubbish often proves to span thousands of years, leaving it uncertain which particular piece of rubbish was contemporary with the paintings. Second, archeologists tried to place paintings in a temporal sequence on the assumption that art styles progress from simple (schematic, monochromatic, face-on depictions) to complex (realistic, polychromatic, using more difficult perspectives). However, this method is completely circular, since the goal is to trace style changes from known dates rather than vice versa. In addition, as we know from our own experience, paintings that unsuspecting historians might have placed 10,000 years apart on stylistic grounds were created during some of the same decades of the twentieth century.

Just this year, a new technique has yielded the first absolute dates for some well-known Cro-Magnon paintings—and those dates have included some surprises. The technique relies on an instrument called an accelerator mass spectrometer, which separates and counts individual carbon isotopes and thus requires only tiny amounts of carbon from charcoal-based black paints themselves. Three of the famous bison at Altamira prove to have been painted 14,000 years ago. A bison at the nearby cave of El Castillo, previously considered contemporary with the Altamira bison because of stylistic similarity, was actually executed a thousand years later. Another bison from the Black Room of Niaux, previously assumed to have been painted much later, actually dates to about 12,900 years ago, making it virtually contemporary with the El Castillo bison. These results confirm that styles do not develop in a straight line and that a given year's paintings need not be stylistically homogeneous.

One new technique involves dating the mineral "varnishes" that accumulate naturally over a cave painting, and still another is based on analyzing the chemical composition of the paints. Like modern paints, Cro-Magnon paints consisted of pigments to which were added plant, animal, or mineral binders that improved paint adhesion and prevented cracking. Cro-Magnon binder preferences, and hence paint composition, changed with time, allowing u to date Cro-Magnon paintings in the sam way that we can recognize forged "m dieval" paintings by the modern chemica in their paints. Other new approaches understanding Cro-Magnon artists wi come through analyzing the footprint handprints, and fingerprints that they le in the caves. Those approaches may tell u how many different individuals created th paintings, and how closely they were re lated to each other and to modern Euro peans, since fingerprints are geneticall determined.

All these are ways in which modern sc ence can teach us about art of the remo past. But there is also an important lesso that Cro-Magnon art—in particular, i sudden end—can teach us about our ow future. Cro-Magnon art reached a brillia summit at the end of the ice ages, in the sc called Magdalenian phase, when A tamira's Great Hall, the bulls and horses Lascaux, and the Black Room of Niau were painted. The next archeologica phase of southwest Europe, termed th Azilian, produced no cave paintings at al Cro-Magnon sculptures, engravings, jew elry, and other art forms also vanished

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he sole surviving art from the Azilian nsists of crude spots of almost mono- romatic paint daubed on pebbles. More an six thousand years were to pass be- re western European art began to regain e quality reached by the Cro-Magnons. is as if Cro-Magnon society had been mbed back into the Early Stone Age, l the survivors too stunned to be able to nt. What actually happened?

To judge from the number of archeolog- l sites, western Europe's human popu- on was much lower in the Azilian than he height of the Magdalenian. To judge n the geographic distribution of human facts, the Azilian's survivors practiced ch less long-distance trade, moved ter distances, and depended more on al resources than had the Cro- gnons. Europe's cultural unity fell into ments.

What might have caused this collapse? abundant big game on which Cro- non civilization had depended van- l. Mammoths and woolly rhinos be- e extinct; horse, bison, and red deer lations declined in western Europe; loving reindeer vanished from France Spain and retreated north to Scandi- ; and cold-loving ibex retreated to- the tops of Europe's mountains. In the cause of these population crashes wofold: global warming at the end of leistocene ice ages, plus overkill by creasingly sophisticated weapons of ng numbers of Cro-Magnon hunters. nk of that chain of events: human ation explosion; destructive tech- es; global warming; a crash in food ; a crash in human numbers; the ors fragmented into local bands, out h with each other; a collapse of civ- n and art; people reduced to daub- ts of paint on pebbles. It all sounds iliar because it is the oft-discussed mental holocaust that we fear may our children in the twenty-first cen- hile our sophisticated weapons are ger made of stone or wood, and e ourselves, rather than astronom- les, are the cause of today's global g, the scenario is otherwise eerily l. Is the whole world now spiraling to another Azilian age? The mean- Lascaux's horses may remain in- e, but there is no misreading the warning to us.

iamond is a professor of physiol- UCLA Medical School, and a re- ssociate in the Museum's depart- rnithology.

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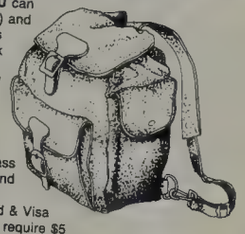
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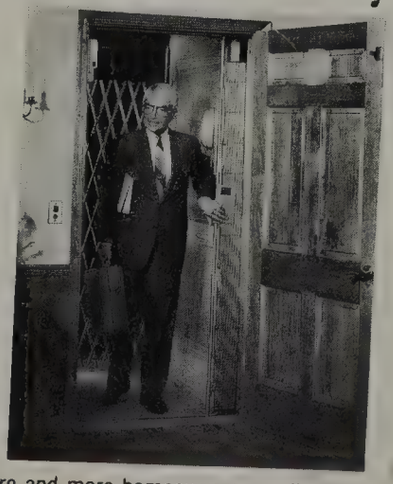
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Black Branch Barrens, Texas

by Robert H. Mohlenbrock

Barrens—natural forest openings with prairie plants—are habitats that the Nature Conservancy ranks as threatened around the world. In a dry, upland region of the Angelina National Forest of southeastern Texas, the oak and hickory woodland contains barrens noteworthy for the rare plants that grow there. The area has been little disturbed, although it lies just three miles from the region inundated by the Sam Rayburn Reservoir.

Naturalists employ the terms *barrens, glade,* and *prairie* for forest openings with prairie plants, frequently using them interchangeably. Botanist Alice Heikens defines them more precisely, on the basis of soil and vegetation. Prairies and glades are both openings containing few or no trees and shrubs. Prairie soil has no exposed rocks, while a glade has rocks of various sizes scattered over the surface. Glades may be further classified by the nature of the rocks—sandstone, limestone, dolomite, and granite. Small trees may take hold in the crevices between some of the rocks. Barrens may or may not have rocks; what distinguishes them is that the prairie vegetation grows beneath a canopy of trees, which are usually stunted.

Black Branch Barrens, covering half a square mile, fits Heikens's definition of barrens because small trees are scattered across the undulating terrain. Such habitats are now rare in North America, in part because so much land has been cleared for agriculture. Elsewhere, the suppression of natural fires has disturbed the ecology, allowing forest vegetation to take over.

The blackjack and post oaks at Black



Connie Thompson

Navasota ladies'-tresses, left, is an orchid that grows at Black Branch Barrens. Stunted by poor soil and periodic ground fires, the barrens' trees, above, allow considerable sunlight to reach the forest floor.

Paul Montgomery

Joe LeMonnier



Black Branch Barrens

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Branch Barrens are stunted—most are less than thirty feet tall—because the soil is poor in nutrients and dry much of the year. Low-intensity ground fires caused by lightning strikes have also discouraged the encroachment of woody plants. Shrubs that grow along with the oaks include wild privet, parsley-leaved hawthorn, and high-bush blueberry. The trees and shrubs are spaced far enough apart to provide areas with little shade, favorable to the growth of prairie species.

Clumps of little bluestem, pineywoods dropseed, and other bunch grasses dot the ground, while the most common wildflower is Nuttall's rayless goldenrod, a plant lacking the yellow, petallike rays of the more familiar goldenrod. Pink milkwort, baptisia, neptunia, rough buttonweed, Texas coneflower, five kinds of blazing-stars, and pencil-flower, all typical of dry, open areas, grow in abundance. Here and there rattlesnake-master raises its spherical flower heads, belying its membership in the carrot family, which usually has flowers in umbrella-shaped clusters. Lichens are also common in the barrens.

According to Steve Orzell and Edwin Bridges, both southeastern botanists, Black Branch Barrens is enriched by a number of plants endemic, or unique, to the West Gulf Coastal Plain, as well as some species with sporadic distributions that are rare in southeastern Texas. Navasota ladies'-tresses, a small white-flowered orchid that has been listed as endangered, is one of the endemics. Others are golden hedge hyssop, which is a bright, golden-yellow wildflower related to the snapdragon, and slender gay feather, which has a few lavender-purple flowering heads arranged on a very slender spike. Nearly endemic is Texas sunnybells, a member of the lily family with small, bell-shaped flowers. Among the rare plants Orzell and Bridges have recorded at the barrens are Drummond's sandwort, least daisy, San Saba pinweed, Nuttall's milk vetch, western dandelion, Texas saxifrage, and smooth phacelia.

Botanists K. L. Marietta and E. S. Nixon have attempted to shed light on why this plant community has arisen here. They report that the topsoil is only about two feet deep but contains an accumulation of clay, so that water seeps through it slowly. The clay is montmorillonite, the same type of spongy clay that is gradually creeping down Colorado's Mesa Seco t form Slumgullion Slide (see *Natural His tory,* April 1989). During the cooler rainier seasons of the year, the soil be comes saturated, but in late spring an summer, it dries out and develops cracks In addition, the soil is low in some nutri ents, such as phosphorus. The rare plant in the barrens apparently do well unde these conditions, perhaps in part becaus the growth of potential competitors is dis couraged.

A woodland of post oak, blackjack oak and black hickory, with occasional winge elm and water oak, surrounds the barrens Because of the better soil conditions, th trees may grow seventy-five feet high Common shrubs are wild privet, high bush blueberry, two kinds of hollies, an two kinds of hawthorns. The grasses an wildflowers include narrow-leaved se oats, woodland buttercup, black snake root, small-flowered skullcap, and blue leaved sage, all species characteristic o shady forest floors. Only a very few of th barrens' prairie species can survive be neath the abundant trees. □



Golden hyssop are wildflowers unique to the West Gulf Coastal Plain.
Robert Evans

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A muriqui leaps across a gap in the canopy of Brazil's Atlantic forest. Although the monkeys may weigh twenty pounds or more, they are very agile, often traveling rapidly through the trees in search of food.
Andrew L. Young

Menu for a Monkey

The muriquis' diet may reveal the medical riches of a South American forest

by Karen B. Strier

The muriquis were on the move again, swinging hand over hand through the trees in single file as fast as I could count them. I stumbled in pursuit down the overgrown trail, skipping over protruding roots in an effort to avoid falling flat on my face. The monkeys were already out of sight by the time I reached the valley bottom and began the steep climb up the opposite side. But as I stopped on the crest of the ridge to catch my breath, excited neighs and chirps coming from a large fig tree on the slope below gave away the muriquis' location. Less urgently now, I left the trail and made my way through the dense undergrowth to a spot where I could sit and watch the entire group almost at eye level.

The canopy of the tree was laden with fruit—the muriquis would enjoy a respite of several days following the difficult trek they had made that morning. They would camp out here, feasting on the abundant ripe figs until the fruit was nearly depleted and it was time for them to search for their next meal. Then they might lead me on another long, high-speed chase through the forest or meander at a more leisurely pace, eating leaves along the way, until they discovered another fruit tree where they would camp out again.

After studying the same group of muriquis, or woolly spider monkeys, over the past decade, I have grown accustomed to what at first had seemed to be their unpredictable behavior. Part of my early confusion was the result of how little was known about this primate when I first traveled to their homeland, the Atlantic forest of southeastern Brazil. But scattered observations by a handful of scientists, as well as anatomical descriptions of museum specimens, had raised an intriguing question.

Muriquis are the largest monkeys in the New World, with adults of both sexes weighing twenty pounds or more. Their large bodies signal that they, like many other large-bodied primates, have a relatively low metabolism. This allows them to subsist on leaves, a food that is easily obtained in large quantities but is low in readily available energy. Their well-developed jaws and chewing muscles and sharp, crested molars enable them to break open the leaves' tough cell walls, releasing the nutrients stored inside and making them easier to digest. In this respect, muriquis resemble howler monkeys, which live throughout much of Central and South America.

Yet muriquis do not share the howlers' slow, quadrupedal method of climbing through the trees. Instead, they swing through the branches by their arms, an energetically costly mode of travel, better suited to tracking widely dispersed but energy-rich food sources, such as fruit, rather than the more ubiquitous leaves. This "suspensory" locomotion is a trait that muriquis share with their closest cousins, the spider monkeys, which live in Central America and in the Amazon basin. According to primatologist John Cant, spider monkeys can specialize in eating fruit because they can cut down on travel time.

To reconcile the evidence of seemingly





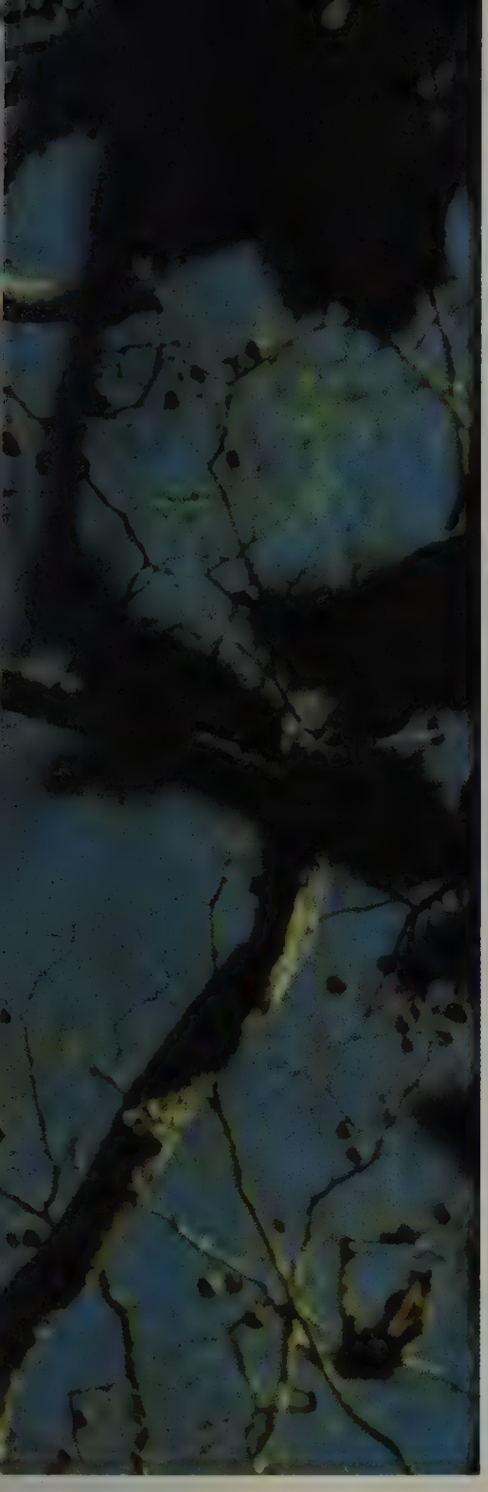
contradictory feeding adaptations, I set out in 1982 to study muriquis in the wild at the 3.5-square-mile forest at Fazenda Montes Claros in Minas Gerais, Brazil. I quickly discovered that what muriquis eat is only one of the notable characteristics of this species, for unlike nearly all other primates, muriquis live a social life strikingly free of aggression. Fights never break out within groups over access to food or the best feeding sites, and there is no discernible pecking order. Group members simply wait patiently for their turn to eat, and they avoid feeding so closely together as to interfere with one another.

The rules of etiquette among muriquis extend well beyond their courteous dining manners, for relations between the sexes are egalitarian. The muriquis live in groups that include several adults of both sexes, as opposed, for example, to just females and one adult male. Among most other primates that live in such groups, the males are better equipped than the females for combat, being larger and having bigger canines. The males typically compete for mates, establishing a hierarchy by fighting among themselves. The dominant male can monopolize the mating scene and can bully the females into sexual liaisons.

But the muriqui males and females are similar in size, so males can't dominate the females. And it is futile for males to fight among themselves for mates, since females are free to choose peaceful mates. All this appears to result from the muriquis' mixed diet. Because the monkeys rely at times on eating nothing but leaves, males and females are relatively large. At the same time, the need for agility in the long-distance pursuit of fruit limits hov much bigger males can become.

Since a single male cannot dominate th group, the male muriquis' strategy is fo close male relatives, brothers as well as fa thers and sons, to stick together in a tole ant group. Instead of competing amon themselves, they cooperate to prevent en croachments from other groups of males while taking advantage of whatever sexua opportunities the females throw their way So even if a male muriqui does not hav offspring of his own, he is assured that th similar genes of a close relative will b passed to the next generation.

It took me a long time to crack the cod of muriqui social behavior becaus muriquis do not reach sexual maturit until they are about seven years old. B this age, nearly all the females born in th



A fruit tree, left, provides a group of muriquis with easily digested, energy-rich food. The group will camp out there until the supply is exhausted. An adolescent male muriqui, below, will remain in his natal group throughout his life. The distinctive mottling that develops on the muzzles of the monkeys as they mature enables researchers to identify and track individuals over the years.

Both photographs by Karen B. Strier



rincipal group I was observing had mi-rated out. The nexus of the society con-ists of the associations among the older nales born to the group, their mothers and ounger brothers, and young immigrant emales.

In the past ten years, this muriqui group as more than doubled in size, from wenty-two members to the current forty-ine, each one distinguishable by its nat-ral markings. Important social changes ave coincided with this population rowth, including a greater tendency for his once-cohesive group to split into maller, temporary mixed-sex groups. Eventually it may divide permanently, but o far the entire group still tends to reunite vhenever large concentrations of fruits, uch as figs or the deliciously sweet wild nangoes, are discovered.

In recording the monkeys' diet, I observed pronounced variation from month to month, owing to seasonal differences in rainfall and available food. Over an annual cycle, the muriquis at Fazenda Montes Claros devote roughly half of their feeding time to leaves; one-third to fruit; one-tenth to flowers and flower products such as pollen and nectar; and the remainder to bark, bamboo, ferns, and grasses, which they come to the ground to eat. But despite the high contribution of leaves to their overall diet, muriquis almost always prefer to eat fruits and flowers, settling down to a protracted banquet whenever they can.

The pursuit of energy-rich fruits and flowers appears to dictate the muriquis' far-ranging movements. When these foods are scarce, muriquis travel faster and farther to find them. In contrast, leaves are usually eaten haphazardly when the monkeys are shifting from one fruit source to another and are paid little more than passing attention unless fruit is in short supply. But by consuming both types of food, the muriquis have evolved a successful adaptation to the Atlantic forest, which because of its distance from the equator is more seasonal than, for example, the Amazon basin, where energy-rich fruit is available year round.

In its adaptation, the muriqui differs from the brown howler monkey, which occupies the same Atlantic forest habitat and lives a lazier life, filling up mainly on leaves. The muriquis' digestive system cannot handle such a limited diet. Howler monkeys have elongated intestines relative to their body size, and there is ample time for nutrients from leaves to be absorbed as food travels slowly through their gut. Muriquis also have proportionately long intestines, but food passes through them much more rapidly. In a study of captive animals, primatologist Katharine Milton found that food passed through a muriqui's digestive tract more than twice as fast as it did through a howler monkey's. In the wild, muriquis defecate every few hours throughout the day, whereas the howler monkeys defecate just once after waking in the morning and once before nightfall.

While the muriquis' faster digestion prevents them from subsisting on leaves alone, it also provides an advantage: they



iz Claudio Marigo

Only one pair of twins, opposite page, was born in the muriqui group monitored by the author for the past ten years. As the infants matured, the overburdened mother could carry only one. The other managed to tag along but eventually disappeared, perhaps lost in some mishap. Below: Resting in the branches, a male muriqui (center) examines a female's genitals while her son and a playmate look on.
Andrew L. Young



on't have to be as careful as howlers bout what leaves they eat. Primatologist Kenneth Glander found that although Costa Rican howler monkeys eat substanal quantities of foliage, they are highly elective about what leaves they forage n, avoiding those with high levels of tanins and compounds such as alkaloids and henolics, which can be anything from ildly to severely toxic. Plants produce ese often unpalatable chemicals to deend themselves against insects and other nimals that might consume them.

Howler monkeys must be extremely hoosy about their foods because their ore deliberate digestive systems make em vulnerable to absorbing toxic comounds along with essential nutrients, but e muriquis' quick processing means that lant tannins and toxins, as well as many utrients, are excreted before they can be bsorbed. Ecologist Mark Leighton and hemist David Marks analyzed some irty muriqui foods I had collected from e forest—fruits, leaves, and flowers—nd found them to be unusually high in annins and phenolics when compared ith similar foods eaten by other monkeys nd apes in other tropical forests. And hen we compared the plants normally vailable at the same times of year, we ound no evidence that the monkeys seected the ones with lower levels of tanins or other harmful compounds.

These biochemical and physiological ata made sense of my observations that uriquis generally prefer fruits over eaves despite the greater effort required to nd them. Ripe, fleshy fruits, in particular, re usually easier to digest than leaves and us, ounce for ounce, are a better source f nutrients and energy for a primate with uch a rapid food-passage rate.

Sorting out muriqui feeding habits ould have marked the end of my study, ut by 1989 two new questions had begun o intrigue me. With the help of Brazilian tudents who follow the muriquis year ound, I had accumulated enough demoraphic data to detect a consistent birth eason during the dry months, from May to September. I wondered whether this might be related to the muriquis' seasonal diet. And after reading two separate accounts of chimpanzees consuming plants with medicinal properties when they were suffering from intestinal parasites, I wondered whether the high level of the defensive plant compounds in the muriquis' diet provided them with similar protection.

These questions could be explored simultaneously because they shared a common denominator—diet. But how could I examine the effects of diet on reproduction, when female muriquis showed no visible signs of ovulation or pregnancy? And how could I detect parasitic infections, when the parasites were hidden in the gut? Capturing the monkeys—to take blood samples to measure ovarian hormones or to probe their intestines—was out of the question. The muriquis are an endangered species, and I did not want to

Andrew L. Young

An adolescent male chews leaves, below, taking advantage of an abundant source of food. Right: A baby clings to the back of its mother.
Andrew L. Young; Photo Researchers





subject them to possibly harmful procedures, nor did it seem worthwhile to disturb them and thus risk interfering with the long-term behavioral study.

After considering all kinds of sophisticated approaches, I realized that the solution to this dilemma lay in a naturally abundant and renewable resource: the muriquis' feces. To examine ovarian hormone levels, I began collaborating with reproductive endocrinologist Toni Ziegler, who developed a technique to monitor muriqui feces for estrogen and progesterone. And biologist Michael Stuart, whose specialty is identifying parasites in dung, has helped me in investigating muriqui intestinal parasite infections. By following recognized individuals until they defecated, I could collect the fecal samples needed for these studies and also keep track of what the muriquis were ea ing. Phytochemist Eloy Rodriguez is ana lyzing muriqui plant foods for steroids an bioactive compounds, and by combinin the results from these studies, we will ult mately be able to evaluate the relatio ships between muriqui diet, reproductio and parasite infections.

While simple in theory, my role in thes investigations has not been easy. The bi chemical analyses of the plant foods re quire gathering a grocery bag full o leaves or fruit from each plant species, an doing this after the muriquis hav swarmed through one of their feedin trees is not as simple as it sounds. Collec ing fresh fecal samples from identified in dividuals is equally laborious. The fece themselves are not so unpleasant to colle as one might suppose because they carr



n aromatic scent from the cinnamon eaves that muriquis consume. The chal-enge, rather, is to get almost directly un-lerneath the targeted individual at the mo-nent of defecation so that the greenish rown dung can be spotted before it is amouflaged after hitting the ground.

Occasionally the feces land neatly in ny glove, but more often they splatter use-essly in the tangled vegetation—or else all alongside another muriqui's feces, so hat I cannot be sure whose is whose. So even though the muriquis defecate often nd, in the case of adults, abundantly each ime, getting a clean sample sometimes neans tailing one muriqui for up to six ours without pause.

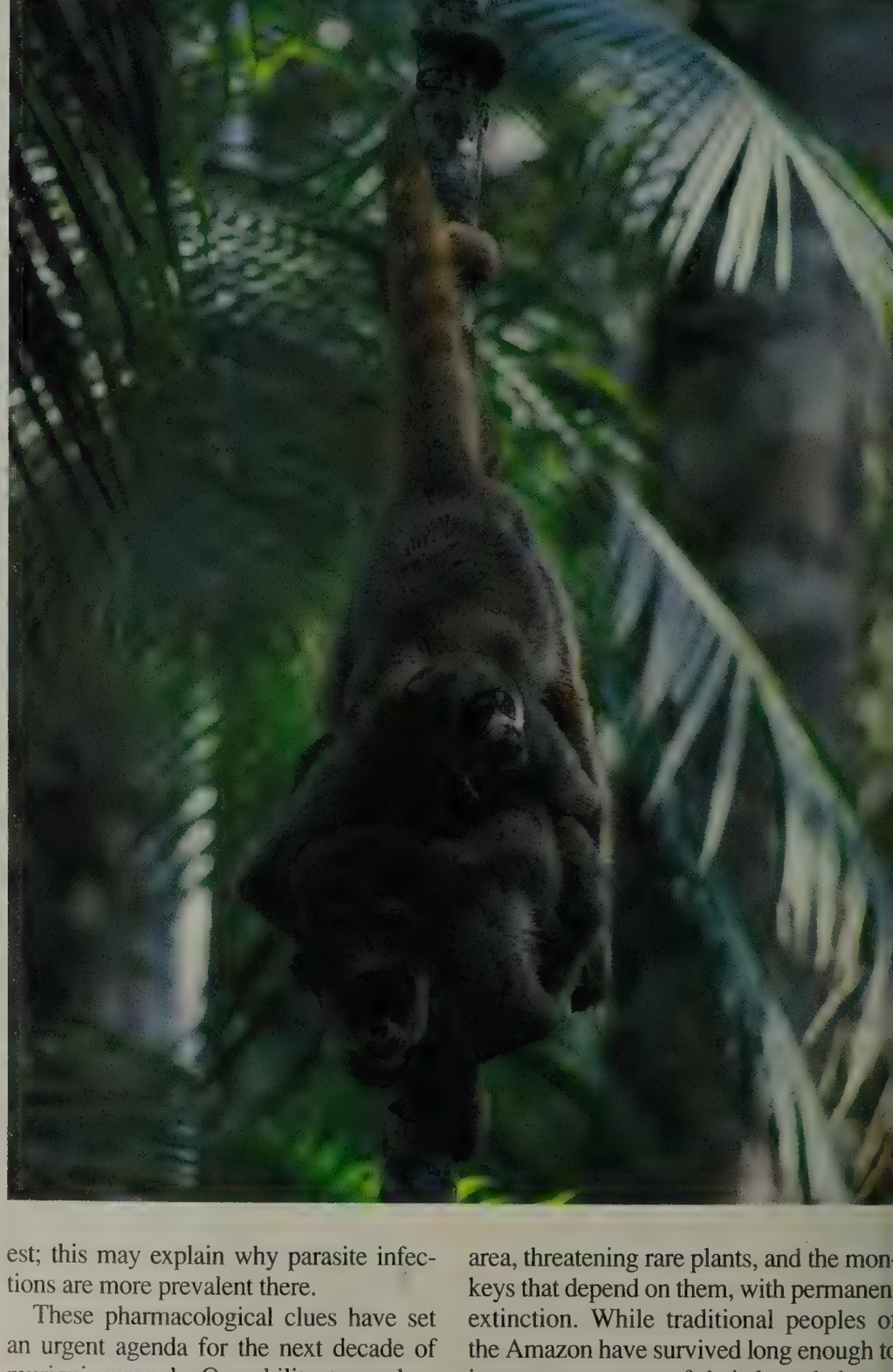
The rewards for these efforts are new indings as promising and intriguing as verything else we have learned about muriquis. At Fazenda Montes Claros, October is the onset of both the rainy season and the muriquis' mating season, and at this time the muriquis' feeding behavior changes. From late September to mid-October, when edible fruit abounds, the monkeys eat mainly the leaves of just two species in the legume family, *Apuleia leiocarpa* and *Platypodium elegans*. And in contrast to the casual treatment they give most other leaves, the muriquis camp out at these leaf sources, behaving as if they were preferred fruits.

Preliminary analyses suggest that these leaves may contain some antimicrobial substances and are exceptionally low in the tannins so prevalent in other muriqui foods. The chemical role of tannins is to bind proteins and make them more difficult to digest, rendering plants less attractive as food sources. By eating these leaves instead of the fruits available at this time, both male and female muriquis may get an important surge in protein, fortifying them for the upcoming mating season.

During this same critical time of year, muriquis also alter their behavior by making speedy excursions away from the central part of the forest, where they usually hang out, to the periphery, where the forest gives way to surrounding pasture. Once there, they leap across gaps in the canopy to reach the fruit of another species of legume, *Enterolobium contortisiliquum*, whose common name is monkey ear. Uncharacteristically, both male and female muriquis abandon the monkey ear trees long before the fruits are depleted, suggesting that they only need a taste to be satisfied.

The friendly embrace of two males, below, typifies the peaceful relations within the group. The group's males, which are closely related, cooperate in chasing away any rivals from outside. Right: Muriquis rest in the branches of a tree.

Both photographs by Luiz Claudio Marigo



What they are seeking in these fruits is unknown, but monkey ear fruits contain stigmasterol, a steroid used in the laboratory synthesis of progesterone. We don't know yet whether this plant hormone also stimulates steroid production in muriquis or whether it is excreted without consequence. But recent studies, including one by anthropologist Pat Whitten, indicate that plant hormones can regulate reproduction in some animals. Thus stigmasterol, or some other hormone lurking in the muriquis' diet, may turn out to be linked to the monkeys' seasonal fertility.

That plants regulate muriqui reproduction remains a highly speculative proposition, but that they combat parasites is more apparent. Our first analysis showed that the muriquis at Fazenda Montes Claros were completely free of intestinal parasites, a discovery so startling that we repeated the fecal sampling during different seasons in subsequent years and looked at samples from the local howler monkeys for comparison. We also collected feces from another population of muriquis inhabiting the much larger and more pristine forest at Carlos Botelho State Park in the state of São Paulo.

The subsequent analyses confirmed and extended our original findings: No parasites were found in the muriquis and howler monkeys at Fazenda Montes Claros, while at Carlos Botelho at least three species of parasites were identified and nearly 90 percent of the monkeys sampled were infected. Such marked variation could result from any number of differences between the two sites, but it may be more than mere coincidence that many of the plants eaten by both muriquis and howler monkeys at Fazenda Montes Claros are the same species used by Amazonian peoples for controlling intestinal worms and other parasites. If these plants are effective in humans, there is every reason to believe that they are similarly effective in muriquis, even if in muriquis the effects are incidental rather than intentional. Far fewer of these medicinal plant species have been identified at the São Paulo forest; this may explain why parasite infections are more prevalent there.

These pharmacological clues have set an urgent agenda for the next decade of muriqui research. Our ability to explore the medicinal properties of plants in Brazil's Atlantic forest is jeopardized by continued habitat destruction. In the past century, the Atlantic forest has been reduced to less than 5 percent of its original area, threatening rare plants, and the monkeys that depend on them, with permanent extinction. While traditional peoples of the Amazon have survived long enough to impart to us some of their knowledge of forest plants, the indigenous human societies of the Atlantic forest are long gone. The muriquis and other monkeys may provide humans with their best guides to the forest's medicinal value. □




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A 370-million-year-old fossil, left, from deposits near Gilboa, New York, reveals the head and upper body segments of the earliest known centipede.
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One Small Step for an Arthropod

In a giant leap in the history of life, invertebrates set foot on land more than 400 million years ago

by William A. Shear

As the sun goes down over a tropical swamp, mist begins to form, drifting in wisps among the stems of leafy plants growing along the margins of a sluggish, shallow stream. Down in the mat of fallen, decaying stems, life stirs. A spider watches for prey at the entrance to its silk-lined burrow. It may not have to wait long; a centipede is forcing a path between the tangled stems. Before it reaches the spider's burrow, the centipede suddenly swings its flattened head to one side, snatches its own prey, a primitive-looking wingless insect, and immediately begins to feed. Nearby, another tiny predator grooms its appendages. It is a false scorpion, which will soon begin a slow, blind hunt amid the debris, using long hairs extending from its pincerlike palps to detect the movements of mites and other small creatures.

While this vignette could describe the night life in nearly any community of soil- and litter-dwelling animals today, some of these creatures are definitely unfamiliar. When the false scorpion does detect and capture its prey, the victim is likely to be a small, flattened, multilegged animal quite unlike anything even the most observant soil ecologist has ever seen. Abundant among the predators are animals that, for all their similarity to spiders, lack the typical spider silk-spinning apparatus and have armor-plated bodies and unusual compound eyes. Even the plants in our scene have a curiously primitive look. Despite the tropical environment, there are no trees; only shrublike plants grow above a tufted mat of tall but mossy herbs.

The combination of the familiar and the strange should tell you that you have been indulging a paleontologist in a favorite pastime: imagining what life might have been like when ancient plants and animals, now known only by traces in rocks, were alive. The brief story I have told is from the Devonian period some 370 million years ago and might have taken place along the Hudson River not far from New York City. The scene is of special interest because it reflects a stage in an important, ongoing process in the earth's history: the populating of the continents with plants and animals. Like other scenarios of ancient life reconstructed by paleontologists, this one is supported by evidence from the fossil remains of animals. Most of that evidence has come to light only in the past twelve years.

In 1981, I attended a scientific meeting in Radford, Virginia, where I met a colleague from Scotland, Ian Rolfe, who was on an extended visit to the United States to study arthropod fossils. At that time, I would have been hard pressed even to recognize an arthropod fossil, aside from the common trilobites. All my research involved the systematics and evolution of living arthropods, especially arachnids (spiders and their relatives) and myriapods (millipedes and centipedes). Ian had just visited a paleobotanical, or fossil plant, laboratory at the State University of New York at Binghamton in upstate New York



A centipede guards its eggs.
Photographs by William A. Shear

and had brought back pictures of some unusual fossils. If I liked, I could see them the next morning at breakfast. That event turned out to be a pivotal moment in my research career and brought out the hidden paleontologist in my makeup.

The pictures were of tiny specks of brown matter that had shown up with plant fossils. When I examined the pictures, I felt as if I were viewing samples taken from a contemporary community of litter dwellers, yet Ian assured me that these had come from rocks more than 370 million years old. The level of preservation was remarkable; in some of the highly magnified pictures I could see the creatures' tiny hairs and even the impressions of individual epidermal cells on the outer cuticle, or exoskeleton, they had secreted. The fossils had been discovered nearly ten years earlier by two paleobotanists, Patricia Bonamo and Doug Grierson. Specialists in the study of Middle Devonian plants, they worked in Binghamton, virtually in the center of some of the most extensive Devonian continental rock exposures in the world. When lens-shaped layers of black shale containing plant remains appeared during the excavation for a pumped storage project near the villages of Blenheim and Gilboa, Doug and Patricia were invited to collect material for study. The truckload of black shale from Gilboa that they took back to their lab proved to be rich in beautifully preserved plants of several species.

One of the techniques for extracting material for paleobotanical study sounds quite drastic: immersing fossil-bearing rocks in hydrofluoric acid (HF). HF has the interesting property of being able to dissolve silicates, including glass, which is why it is always kept in plastic bottles. As the rock is eaten away, the fossil material, not affected by HF, is left behind. On examining one treated sample, Doug Grierson spotted a tiny, flattened, spiderlike creature with its legs still stuck in the rock. This whole animal and other, mostly fragmentary ones were recovered and mounted on microscope slides. As the project continued, more animal specimens accumulated and were duly mounted. Doug and Patricia were eager to find a paleozoologist to work with them in studying these remains, but most specialists were skeptical of the extraordinarily preserved but fragmentary fossils.

Paleobotanical labs take extreme precautions to prevent contamination of their samples with contemporary pollen, spores, and plant fragments found in dust. Despite this, scoffers contended that the animal bits had fallen out of the light fixtures or from cracks in the walls. But a good look at the pictures, as well as the story of the original discovery, convinced me that this could not be the case. One fossil, a set of centipede jaws, resembled some I had seen that were unique to a species found today only in Tasmania and New Zealand, and the spidery creature that Doug had found with its legs still in the rock turned out to be a representative of a group of arachnids that had been extinct for about 280 million years.

My excitement about the fossils, and my extensive background in living soil arthropods, convinced Patricia and Dou to let me collaborate with them. Later, v organized an international team of specia ists with unique combinations of experti to work together on these animals. Out these studies has come some of the ev dence we need to reconstruct the way life of tiny soil animals that lived 370 mi lion years ago. My own research ha moved outward to encompass the earlie known terrestrial ecosystems, an excitin field of paleontological work that is chan ing how we think life came to land.

We were able to extract many more fo sils from the Gilboa rock and begin pie ing together the bodies of animals, a pro



Hairs and claws are visible on a tiny, primitive mite from Gilboa. ×1,45

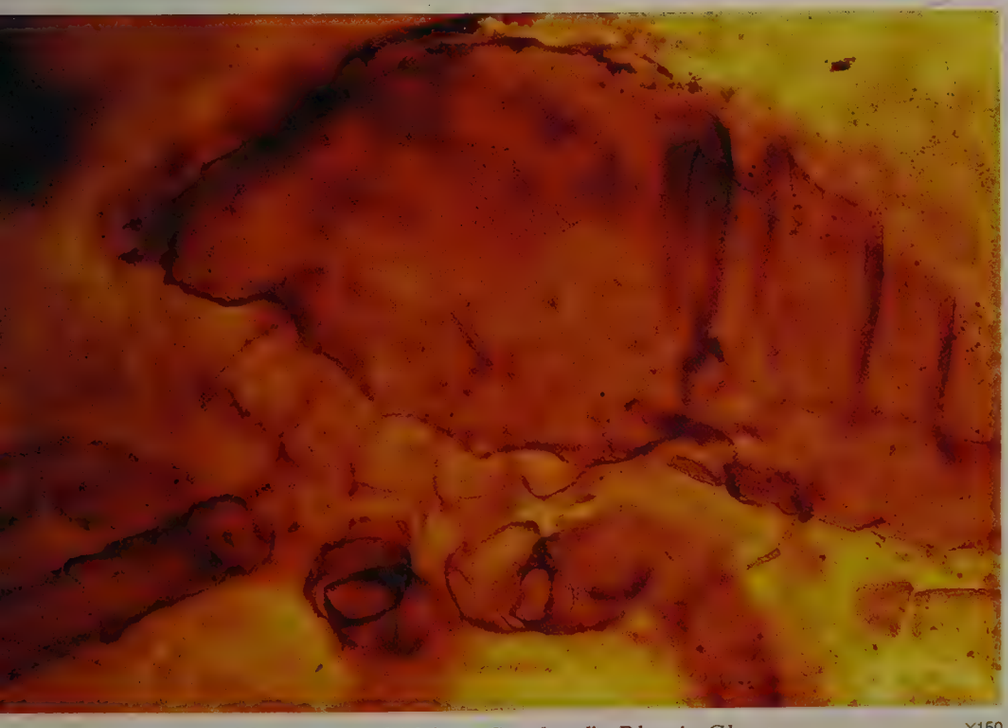
Photographs by William A. Shear

ss not unlike doing a jigsaw puzzle without the picture on the box. While we could e guided in some cases by the living relaves of our ancient arthropods, some of ie fossils have proved to be unlike any reatures we now know. Reconstructing ncient animals, such as the ones in the pening scenario, requires extensive and etailed knowledge of the significance of articular adaptations and the distribution f those adaptations among evolutionary neages.

The ancestry of spiders, for example, is mystery. The first definitive fossil spiers are found long after the close of the evonian, in the Late Carboniferous, about 290 million years ago. But the exact identity of even these fossils is dubious because most of them lack the characteristic adaptations of spiders, especially poison fangs and spinnerets, the small, modified abdominal appendages that carry the outlets, or spigots, of the silk glands. Imagine my surprise, therefore, when a box of Gilboa fossils mounted on microscope slides contained one specimen bearing a beautifully preserved, isolated spinneret. This fragment is the earliest unequivocal evidence of spiders in the fossil record. I contacted two colleagues who had been working intensively on the structure and function of spider spinnerets: Jackie Palmer, of Western Carolina University, and Jon Coddington, of the Smithsonian. We determined that this spinneret could not have come from any group of spiders alive today. The overall appearance of the appendage was vaguely similar to that found in the group of living spiders that includes trapdoor spiders and tarantulas; and the spigots closely resembled those of a much more primitive line, the mesotheles, restricted today to the Asian tropics but probably found worldwide in ancient coal swamps. The spinneret also bore a characteristic cuticular pattern that allowed fossil spider expert Paul Selden, of Manchester University in England, to relate it to dozens of other enigmatic fragments. Paul and I were able to reconstruct a whole leg, locate jaws and poisonous fangs, and put forward hypotheses about how the whole animal (named *Attercopus,* from the Anglo-Saxon word *attercop,* or "poison spider") may have lived. For example, spinnerets with many uniform spigots on one side are often found on spiders that live today in silk-lined burrows, so that habit is suggested for our fossil animal as well. Now that we can recognize bits of *Attercopus,* we expect to be able to reconstruct more of it from additional fossil fragments and speculate further about its way of life.



licknamed the Angry Dragon, a fossil pseudoscorpion used its jaws or self-grooming and to secure and tear apart its prey. ×735



405-million-year-old trigonotarbid from Scotland's Rhynie Chert as book lungs, evidence that it lived on land. ×150

Pat Bonamo discovered one of the smallest fossils from the Gilboa trove, a creature that earned the lab nickname "Angry Dragon" because it looked like a rampant dragon with open jaws. My work with soil animals allowed me to recognize it as a false scorpion, a group of abundant and important soil-dwelling predators that look like minute scorpions without stingers. As with *Attercopus,* this fossil turned out to be the oldest known example of its kind, fully 300 million years older than any previously described. Because of its appearance, we have given it the scientific name *Dracochela,* "dragon pincer." Working this time with Wolfgang Schawaller of the Stuttgart Museum, in Germany, who has studied more fossil false scorpions than anyone else, we came up with a remarkably detailed reconstruction. False scorpions have jaws that are the Swiss army knives of the animal world, tiny but highly varied tool kits serving many functions. For example, the jaws carry special sensory setae, a silk-emitting spinneret, teeth for securing and tearing up prey, and a special set of combs used to clean the other appendages. All these tools were visible on our fossil, thanks to the exceptionally fine preservation. The big pin-

cers of *Dracochela* were studded with sensory hairs called trichobothria, which can work only in air, telling us that these were fully terrestrial animals.

So far, I have mentioned only creatures from our fossil collections that closely resemble other animals still living. What can be done with fossils of groups long extinct? Perhaps the most abundant animals at Gilboa, and at other sites for early terrestrial animals, are the trigonotarbids, or "trigs" for short. Trigs are evidently related to spiders. Their bodies have two basic divisions, cephalothorax and abdomen, as well as six sets of appendages—jaws, leglike palps, and four pairs of walking legs. But unlike those of spiders, trig abdomens are covered by a characteristic series of armor plates and bear no silk-producing organs. We have found no evidence (we've looked hard) of poison fangs, and instead of the simple eyes of spiders, trigs have eyes with as many as ten or twelve loosely packed lenses, an evolutionary reduction from what we think were originally large compound eyes with many tightly packed facets. Trigs first appeared in the Silurian period, about 415 million years ago, and seem to have died out near the end of the Carboniferous period, about 285 million years ago. What does their structure tell us about how they lived?

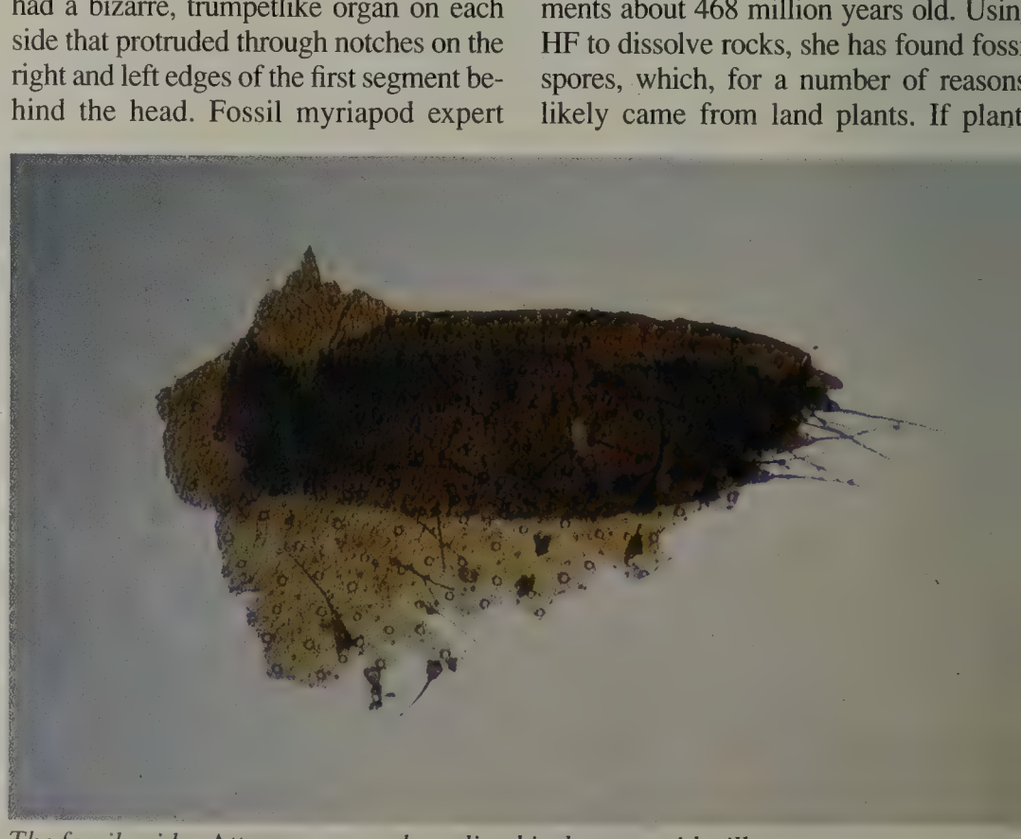
Clues came from another Devonian site, the 405-million-year-old Rhynie Chert, in Scotland, where trigs have been found clustered in the empty spore cases of some of the fossilized plants. This led one group of paleontologists to speculate that trigs ate spores. Yet no living spore-eating animals have robust jaws with long, strong fangs opposing triangular basal teeth and fitted with brushes of setae used to filter liquid food. All these adaptations, found in trigs, are characteristic of animals that capture active prey and digest it by regurgitating enzymes that dissolve the victim's tissue. The predators then suck up the resultant liquid, filtering it through the setae. We found further evidence in the muscle attachment points on the cephalothorax of one of our Gilboa trig species; such muscles might have served to operate the sucking pump. Among our fossils are some wadded masses of arthropod cuticle that are very much like the remains of spider meals, specifically of those spiders with strong jaws for chewing up their prey, presoftened by the spit-up enzymes. Openings on the undersides of our specimens resembled the spiracles, or breathing pores, of living arachnids. This helped confirm another feature of the Rhynie Chert fossils: book lungs, the characteristic air-breathing organs of spiders and their relatives. This provided more evidence that both the Rhynie and Gilboa animals were fully terrestrial.

We also noted that the first few abdominal segments of our trigs were fused and had a heavy transverse ridge. Coupling our information with some that Paul and his student Jason Dunlop had gleaned from Rhynie trigs, we reasoned that the vulnerable junction between the cephalothorax and abdomen of a trig could have been protected by locking the abdominal ridge under the rear margin of the carapace, the upper cover of the cephalothorax. This suggests that trigs had something to fear, perhaps *Attercopus* or one another.

We have also found many specimens of tiny, delicate, multilegged animals that so far have proved very difficult to categorize. We think they may be the precursors of a group of gigantic millipedelike arthropods, the arthropleurids, which grew to more than six feet in length, thrived in the Carboniferous coal swamps, and died out at the end of that period. But our little creatures are at most a quarter of an inch long. We have established that they have ten body segments behind their heads, but we still do not know the number of legs. The heads themselves are difficult to understand; instead of antennae they may have had a bizarre, trumpetlike organ on each side that protruded through notches on the right and left edges of the first segment behind the head. Fossil myriapod expert John Almond, then of Cambridge Unive sity in England, realized that there we two distinctive kinds of posterior ends our fossils. Perhaps this is evidence of tw species or of males and females of th same species. More work will be require to understand these creatures, which a unlike anything alive today.

While the Gilboa site provides the earl est evidence of some of the major group of land animals, the earliest land-livin creatures have recently been discovered Ludford Lane, in Wales, by Andre Jeram, Paul Selden, and colleagues. Usin the same technique—HF digestion rocks—and again using well-preserve plant fossils as guides, they have unco ered 415-million-year-old trigs that a very similar to those found at Rhynie an Gilboa, as well as enigmatic fragments other animals yet to be identified. Ver primitive land plants called *Cooksonia* a found with these animals and may hav created an environment that looked lik living Astroturf. The discovery of wel adapted terrestrial animals at this great ag suggests that applying the same metho to older rocks will push the age of land a imals back in time even further, perhap eventually leading to fossils of the trans tional stages when terrestrial invasion firs took place.

Our optimism is justified by discoverie made by University of Oregon paleo botanist Jane Gray in Ordovician sedi ments about 468 million years old. Usin HF to dissolve rocks, she has found foss spores, which, for a number of reason likely came from land plants. If plant



The fossil spider Attercopus *may have lined its burrow with silk produced by hairlike spigots on its spinneret, above.* Attercopus *may have resembled the modern spider at right.* ×15

William A. Shear

were on land so long ago, could animals have been far behind? Jane Gray's discoveries tell us that the tiny *Cooksonia*, which accompanies the trig fossils of Ludford Lane, may not have been the first land plant.

In the past, we have tended to interpret ancient ecosystems in terms of modern ones. The traditional picture of the development of life on land has followed this pattern: First vascular plants invaded the land, followed at some later time by herbivores, or plant-eating animals, and then even later by predator species. But the communities at Ludford Lane, Rhynie, and Gilboa, spanning nearly 100 million years, are dominated by predators and detritivores, animals that eat dead plant matter. Aside from some enigmatic wounds in Rhynie plants that might have been caused by volcanic cinders or by some other sort of mechanical injury, we have no evidence of animals eating living plants until herbivorous insects first appeared in the middle of the Carboniferous period, nearly 50 million years after Gilboa.

Richard Beerbower, of the State University of New York at Binghamton, has suggested that in Paleozoic terrestrial ecosystems, nearly all potential food from plants had to be at least partly decayed and broken down by detritivores before becoming available to larger animals. He calls this the "litter box" hypothesis. Perhaps the eating of living vascular plants was a habit that took eons to develop. One deterrent may have been the formidable array of toxins and antifeeding chemicals vascular plants contain. These chemicals probably did not appear originally as a response to predation but as natural byproducts of the synthesis of lignin, a compound almost exclusive to vascular plants, and which provides their extraordinary structural strength. Even when herbivorous insects first appeared, their diet seems mostly to have consisted of spores, seed contents, and plant juices, rather than chemically defended leaves.

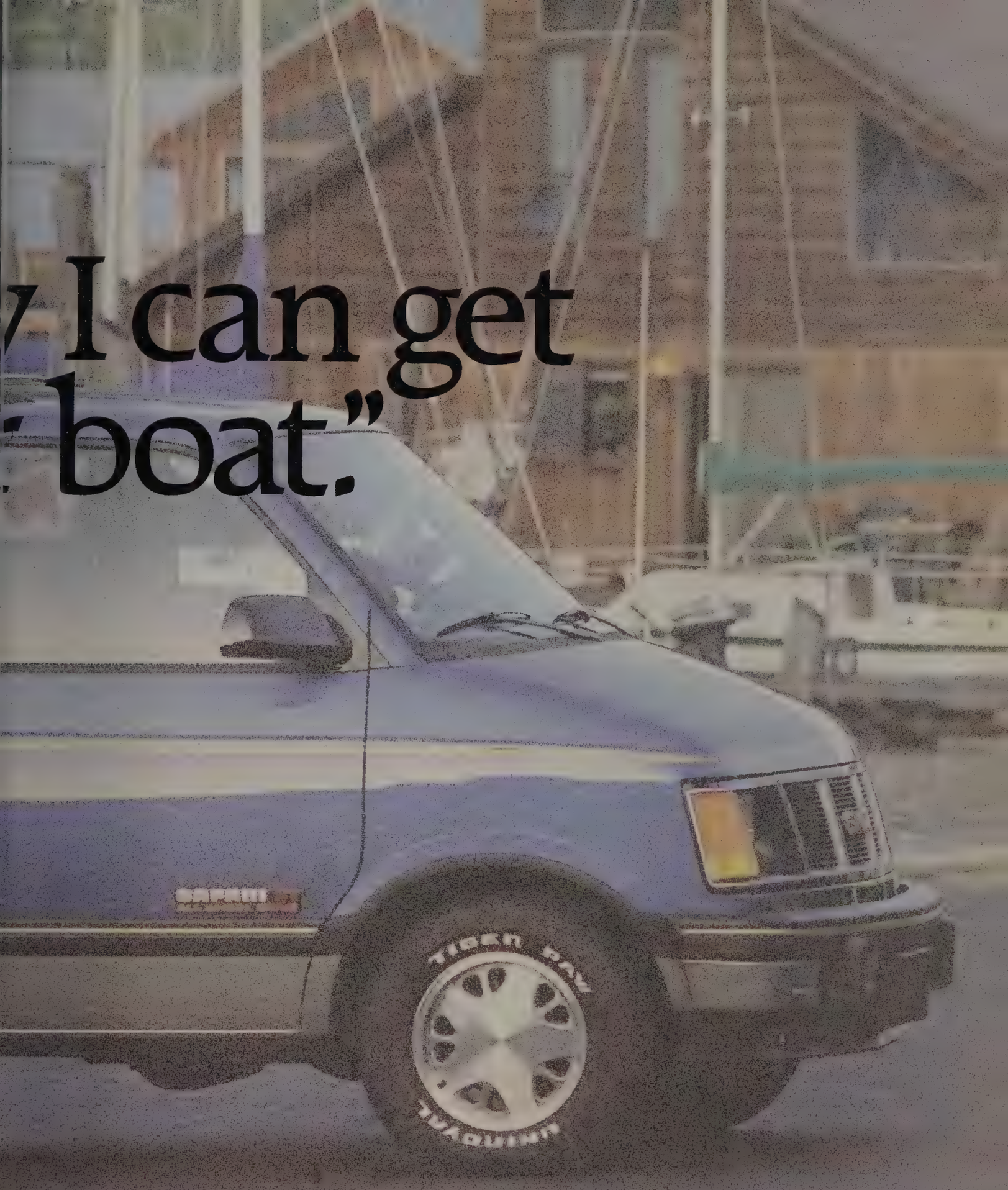
Of course, an alternative is that the few sites we have explored, scattered sparsely through time, sample only soil and litter communities, which even today are dominated by predatory and detritivorous arthropods. Perhaps we do not know what was going on above the soil, among the living plants. Certainly the appearance of large, winged insects in the Middle Carboniferous is deceptively sudden. Where were their ancestors? We have a great deal yet to learn.

We are fairly certain, however, that complex communities of plants and animals were established on land long before our own vertebrate ancestors emerged from the ponds and streams late in the Devonian. But evidence for vertebrates eating vegetation appears only near the very end of the Carboniferous, some 50 million years *after* their apparent emergence on land. Before that, all land vertebrates appear to have been predators, especially on insects. The same story, a long transition to true herbivory, could have been the case with early land arthropods as well.

As we find more fossils to test this and other hypotheses about how early land ecosystems were organized, I think we will discover not similarities, but striking differences between them and our present plant and animal communities. □




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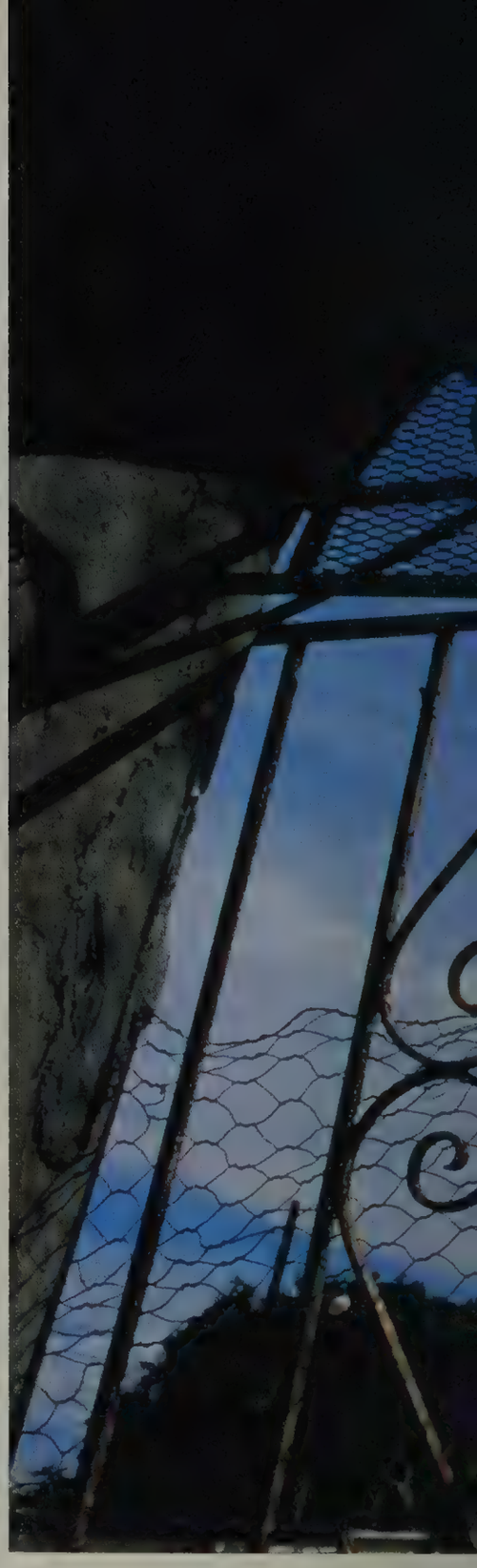
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The gate of the old Jewish cemetery in Charlotte Amalie, Saint Thomas, bears the common Hebrew inscription House of the Living.
Beth Hatefutsoth Photo Archive, courtesy of Mordechai Arbell, Israel

Caribbean Diaspora

Sephardic Jews were an important link between Europe and colonial America

by Samuel M. Wilson

Last summer I was on Nevis for Culturama, that small West Indian island's celebration of its culture. The capital, Charlestown, overflowed with people, who crowded around makeshift booths on the waterfront to buy drinks and such local delicacies as "goatwater" (a spicy stew of goat meat and breadfruit) and "salt fish" (a stewed concoction made from dried, salted cod—a rather improbable historical holdover of colonial English cuisine in a region where fresh fish is always available). The occasion also featured horse and donkey races, the Culturama Queen competition, a contest for calypso singers from all over the island, and a great deal of music and dancing.

Culturama is an enthusiastic celebration of African American cultural continuity and survival despite centuries of oppression. A few blocks away from the crush of people at the booths, a more tranquil scene commemorates a similar lesson in survival. Surrounded by a stone wall, the Jews' Burying Ground leaves a gap the size of a couple of house lots in the middle of the bustling town. Although more than 300 years old, it is neatly tended, thanks to the efforts of the Nevisian government and writer Robert Abrahams, who divides his time between Philadelphia and Nevis.

The twenty or so graves that remain are stone boxes covered by massive stone slabs. Most have a few pebbles and coins on top, put there according to local custom so that the dead will rest in their places and not roam about at night. Placing pebbles on graves is also a Jewish tradition, to show that a grave has been visited recently, but just who adorned these graves is not apparent. Many of the lids are elaborately carved with inscriptions in a combination of Hebrew, English, and Ladino (a language that combines Spanish, Portuguese, and Hebrew elements). Ladino was, and in some parts of the world still is, spoken by the Jews from Spain and Portugal—the Sephardim—who were exiled from the Iberian Peninsula in 1492. The dates on the graves range from the 1680s to the mid-1700s, but the Jewish community existed on Nevis before and well after that time span.

The standard view of Nevis's history is that the island was colonized by members of wealthy English families who exploited slave labor for sugar production. The names on these tombstones, however, show this view to be incomplete. Jacob Alvarez, Abraham Isquiao David Gomes, Daniel Cohen, Abraham Bueno de Mezqueto, Solomon Israel, and several members of the Pinheiro family are buried there. (Isaac Pinheiro's tombstone is also there, but, truth to tell, despite his fervent wish to be buried on Nevis, his body actually lies in the Chatham Square cemetery of the congregation of Sherith Israel in New York City.) All were members of a thriving Jewish community that existed throughout the Caribbean at that time.

The most elegant grave in the cemetery is that of Bathsheba Abudiente, who died in childbirth on August 8, 1684. The Hebrew inscription on her tombstone gives her husband's name as Rohiel Abudiente, but a second inscription in English shows that he also went by the name of Rowland Gideon. An old frangipani, or "temple tree," with deep pink flowers leans over the slab. The Hebrew inscription reads:

This heap be witness and the pillar be witness that in its womb rests the modest woman, a woman of valor, crown of her husband, Mrs. Bathsheba, wife of Mr. Rohiel Abudiente, whose spirit was returned to God after she had borne a son buried next to her, on Tuesday, the 28th day of the month of Ab in the year 5444. For she did what was right in the eyes of the Lord. May her soul be bound up in the bond of eternal life.

Many of the other graves in the cemetery have not withstood the years quite so



well. In some cases all that remains is a fragment of a tomb lid leaning against another grave, perhaps showing part of a name or a few Hebrew letters.

A dirt path still called the Jews' Walk leads south from the cemetery to a nondescript square building full of fifty-five-gallon oil drums, bathtubs, galvanized corrugated roofing, scrap lumber, and other things too useful ever to throw away on a small Caribbean island. The stone facing is of fairly recent construction, but the stonework inside is old and finely worked, with carved columns supporting a vaulted ceiling (the original exterior stones were probably taken for use elsewhere). This building has recently been identified as part of the old synagogue.

Possibly this building adjoined the main chamber of the synagogue, whose location may be marked by the adjacent pile of rubble. It may also have been the building known as the Jews' School, where, along with many others, the young Alexander Hamilton received his earliest education. Born on Nevis in 1755, the future first secretary of the United States treasury was the son of James Hamilton, a young and recently bankrupt Scot, and Rachael Faucitt Lavien, a woman fleeing an unhappy but undissolved marriage on Saint Croix. Because Rachael was not lawfully free to remarry, their children were considered illegitimate by the Anglican church and refused admittance to the Anglican school. So Alexander learned to read and write and to recite the Decalogue in Hebrew as a pupil of the Jews' School. The Hamilton Museum in Charlestown is undertaking the building's restoration, as funds permit.

Other Caribbean islands have monuments to substantial Jewish communities that existed from the early years of European colonization. The Mikve Israel syna-



Samuel M. Wilson

The grave of Bathsheba Abudiente, left, lies in the Jews' Burying Ground in Charlestown, on the island of Nevis. A member of the sizable Jewish community that existed in the Caribbean from the seventeenth century onward, she died in childbirth on August 8, 1684. Below: Miss Culturama is crowned as part of Nevis's week-long celebration of its African American heritage.

Errol Pemberton; E.C.P. Photographics



gogue on Curaçao, built in 1702, is the oldest synagogue in continuous use in the Americas. According to records from 1715, Jews constituted the majority of Curaçao's white population. On Barbados the synagogue of Kaal Kadosh Nidhe Israel, built in 1654 and for a long time unused, was recently spared from demolition and has been restored. Jamaica was settled by Europeans in the first wave of Spanish colonization after Columbus's voyages, and the island was the home of the earliest Jewish community in the New World. Like many such communities, it was made up of Jews who had been expelled from Spain and Portugal in the late 1400s. Others fled the Iberian Peninsula in the sixteenth and seventeenth centuries, as the Spanish Inquisition attempted to identify Jews who had outwardly converted to Christianity but who secretly maintained Jewish traditions. When the English captured Jamaica from Spain in 1655, the Jews joined with the English in exchange for religious tolerance. They were granted British citizenship (something which Jews living in England at the time did not have) and founded a synagogue that very year.

Nevis, although a small island, played more than a minor role in the history of the Caribbean. In the mid-1600s the survival of the North American colonies was not certain, given the strength of Native American resistance. New York City was Dutch New Amsterdam from its founding in 1624 until 1664. The colonies in the Massachusetts Bay area, especially those founded by religious exiles, were not part of the British government's overall colonial strategy and, in any case, were not very substantial in the seventeenth century. Nor were they as profitable as Nevis and other Caribbean colonies. The Caribbean colonies were the British foothold in the Americas before the Chesapeake Bay colonies became profitable, and they continued as strongholds after the American Revolution.

In the seventeenth and eighteenth centuries, Jews played a large part in the economy of the Caribbean. Wills, journals, and other documents compiled by the American Jewish Historical Society and the Jewish Historical Society of England demonstrate that the Jewish community of Nevis had far-reaching associations with Europe and other European colonies in the New World. Those buried in the cemetery on Nevis, many of whom had lived abroad, had had family and business contacts in Lisbon, London, Amsterdam, Calcutta, Brazil, Curaçao, Barbados, Jamaica, Virginia, New York, and Boston. Often these associations were the business links that made Nevis so profitable.

The Atlantic trade in sugar, tobacco, indigo, food, goods, and people was complex, involving exchanges in a half-dozen shifting currencies between markets throughout Europe, Africa, the Caribbean, and the eastern seaboard of North America. Excluded (at least officially) from Spain and Portugal, and discriminated against in much of the rest of Europe, European Jews of the seventeenth and eighteenth centuries found a haven in the Caribbean, where they became traders, shopkeepers, and planters.

The Caribbean was not free of religious intolerance and persecution, however. Nevisian Jews, like most in the Caribbean, were subject to special taxes and prohibitions, and their relations with other groups on the island were often strained. In 1724 the Episcopal minister Robert Robertson wrote to the bishop in London that on Nevis there were

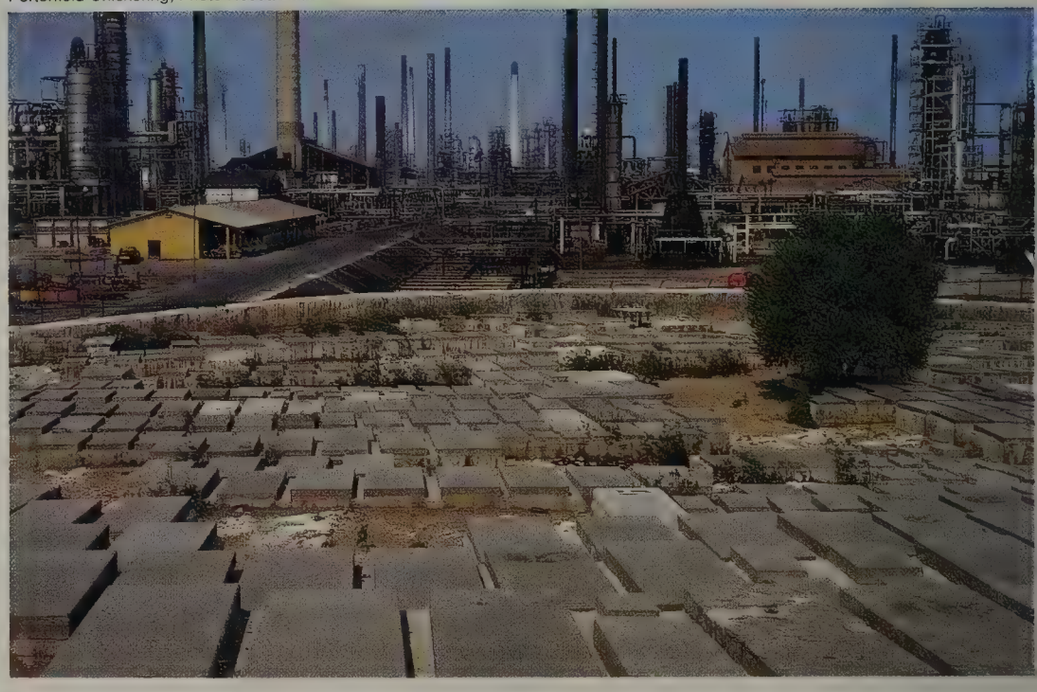
> about 70 householders with their families, being in all (children included) some 300 whites where of one-fourth are Jews, who have a synagogue here and are very acceptable to the country part of the island, but far from being so in the town, by whom they are charged with taking the bread out of Christian mouths. And this, with the encouragement said to be given to the Transient Traders, above what is given to the Settlers, is by many thought to be the true cause of the strange decay of this place—At present there is not above 3 or 4 Christian Families of note in my Parish (*Publications of the American Jewish Historical Society* XX:160).

The Jews of Nevis in the seventeenth and eighteenth centuries also owned slaves of African descent. Many whites of even modest means did at that time in both the Caribbean colonies and in North America. Wills in Nevis contain bequests of slaves, and a 1707 census lists five Jewish heads of households who all together owned forty-three slaves.

Robert Rattner

Beyond a Jewish cemetery on Curaçao, below, looms the Shell Oil refinery. Many Jews came to the island after the Dutch took control from the Spaniards in 1634 and granted religious freedom to the inhabitants. Opposite page: Dating from the eighteenth century, the Honen Dalim Synagogue on Sint Eustatius was built by a congregation whose trading ties extended to North and South America, Europe, Africa, and Asia.

Porterfield-Chickering; Photo Researchers



About Bathsheba Abudiente, the woman with the elegant gravestone, little is known except that she died in childbirth, preceding her husband in death by thirty-eight years. Much more is known about her husband, Rohiel Abudiente or Rowland Gideon. His maternal grandfather was Paul de Pina, of Lisbon, whose family lived outwardly as converts to Christianity. Paul traveled from Lisbon to Rome in 1599, supposedly to become a Christian monk, but instead he became more openly Jewish. He went to Brazil, where there was more religious tolerance than in Portugal, and then to Amsterdam, the city where European Jews enjoyed the greatest acceptance. In Amsterdam, Paul joined the synagogue under his Jewish name, Reuel Jessuram. He was married and had a daughter, Sarah Jessuram. Sarah in time married Moses Abudiente, a member of another of Lisbon's respected Jewish families. Their son, Rehiel (Rohiel) Abudiente, was born about 1650.

Rohiel's early life is not well documented, but by piecing together scraps of official records, we may surmise that he had connections and relatives in several parts of the New World. In 1674, he was listed under his anglicized name, Rowland Gideon, as "Ye Jew" on Boston's first tax roster. Subsequently he moved to Barbados, possibly because Jews there were more readily granted the status of permanent resident in the British Empire. In 1679 Rowland Gideon received such a letter of "denization," which allowed him to reside in any English colony. That year he moved to Nevis and probably married Bathsheba soon after. He stayed there at least until Bathsheba's death in 1684.

Sometime thereafter he moved to London, where in 1694 he married Esther do Porto, a woman of Portuguese ancestry and a member of a powerful Jewish family in London. In 1699 they had a son they named Sampson (or Samson). In 1701 Rowland Gideon was listed as the reader of the Torah in the Bevis Marks synagogue in London, and the next year he became its treasurer. He appears in official documents a few years later representing the Nevis planters in claims for compensation for the French sacking of Nevis in 1709. These proceedings show that Rowland Gideon still held property on Nevis. In 1722 he died and was buried in London's old Jewish cemetery, Bet Hayim.

Rowland Gideon left a considerable fortune to his son, Sampson, who became one of the most powerful money brokers in the British Empire. In 1745, during a period of economic chaos, Sampson arranged a loan of £1,700,000 to the British Crown, and in 1749 he organized a consolidation of the national debt, which reduced its rate of interest. With his close contacts in government, he worked successfully, albeit at great personal cost and against vengeful opposition, to help pass the Jews' Naturalization Act of 1753, which abolished special the taxes and penalties on British Jews.

Sampson Gideon married Jane Ermell, who was from an aristocratic Christian family, and their children were raised in her faith. Sampson withdrew from the synagogue but continued to pay his dues anonymously until his death in 1762. In his will he left £1,000 to the Spanish and Portuguese Jewish community in London, on the condition that he be buried as a Jew in the Jews' cemetery; at the end of his will he commended his soul "to the gracious and merciful God of Israel." He was buried near his father, Rowland Gideon, in Bet Hayim.

As for the Jewish community on Nevis, its numbers began to diminish in the late eighteenth century as Nevis's economic fortunes declined. Some members moved back to Europe, and more moved to the newly formed United States. None of the original Sephardic families lives on the island today.

But in the twentieth century, another migration of European Jews came to the Caribbean. Just as the expulsion of Jews from Portugal and Spain in 1492 forced the emigration of Sephardic Jews in the sixteenth century, the rise of fascism forced Ashkenazic Jews to flee from many parts of Europe in the years preceding World War II. Jewish immigration to the United States was severely restricted in the 1920s and 1930s, so many made their way to the Caribbean islands, where visas could be obtained. They settled in Jamaica, Barbados, Curaçao, the Dominican Republic, and elsewhere in the region. And there they found Jewish communities, synagogues, and cemeteries that had existed for more than three centuries. □



John Pawlic

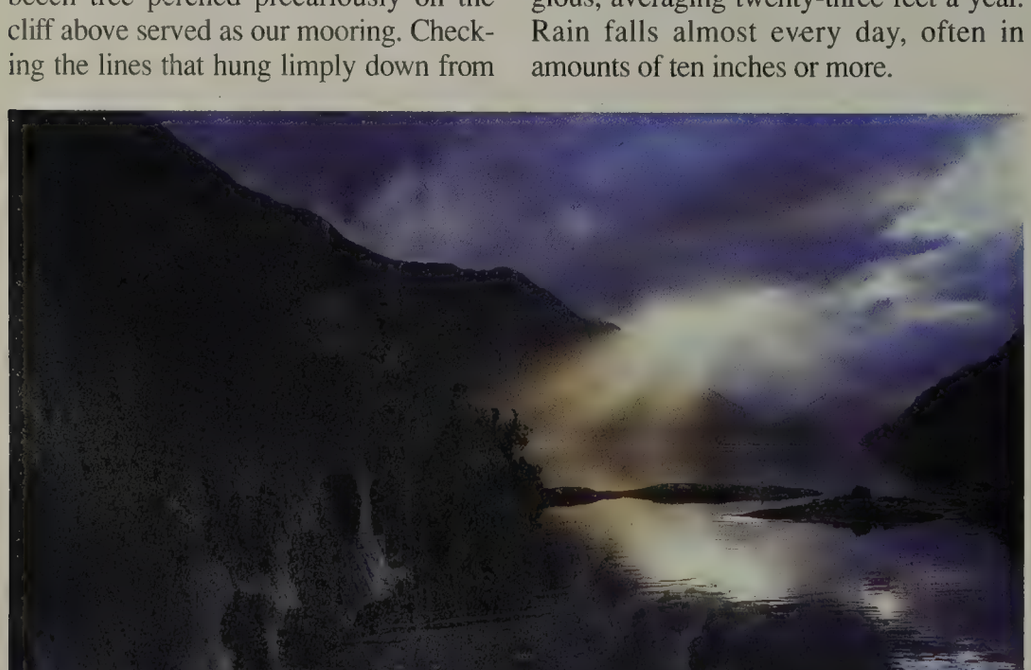
Fiords Down Under

In New Zealand's flooded glacial valleys, forests of deep-sea black coral thrive in shallow waters

by Ken Grange and Walter Goldberg

Something was different when we awoke onboard our research ship in Doubtful Sound, one of the fourteen fiords that penetrate the Southern Alps of New Zealand like fingers from the Tasman Sea. Even before we struggled out of our sleeping bags and up the companionway to the main cabin we could tell that this morning was unusual. The warm wind that had been blowing off the ocean from the west had changed, dropping the air temperature to a chilly 54° F. The weather was just as calm and peaceful as on the previous gray days, but today was brighter. A large beech tree perched precariously on the cliff above served as our mooring. Checking the lines that hung limply down from the beech, we noticed the perfect reflection of the snowcapped mountains in the glassy-smooth water. Only then did we realize that for the first time in more than a week it had stopped raining.

Fiordland, the remote, uninhabited southwest corner of South Island, is New Zealand's largest national park and one of the wettest places on earth. Fiordland lies in the path of winds that blow west across the Tasman Sea. When it reaches the mountainous coast, the moisture-laden air rises and cools, causing the moisture to condense. The resultant rainfall is prodigious, averaging twenty-three feet a year. Rain falls almost every day, often in amounts of ten inches or more.



A rare shaft of sunlight pierces the clouds over Bradshaw Sound, above, one of fourteen fiords on the west coast of South Island. After a heavy rainstorm, right, water cascades down a cliff into Milford Sound. The sheer rock walls and waterfalls are typical of the fiords, which were carved by glaciers.
Darryl Torckler

The sunshine brought out the biting black sand flies, which descended on our bare backs and legs as soon as we stepped out onto the deck. The mottled green rain forest extended almost vertically from the water's edge up to the snow line at 3,000 feet. The tallest mountain peak, rising a mile straight up from the sea, looked close enough to touch in the clear air. The fiords are well known for their spectacular scenery and hiking trails, but we were drawn to them by the unusual marine life discovered here only a decade ago. Although we were ten miles from the open ocean, the 1,000-foot-deep water directly below us harbored schools of marine fish and a resident pod of bottlenose dolphins. Steep underwater cliffs supported rare and unknown species, including many usually found only at much greater depths in the ocean. One of these, the black coral, has been the focus of our research. Black coral usually inhabits deep water, but because of the special conditions in the fiords, enormous colonies of the coral sprout from the underwater cliffs at relatively shallow depths, making them accessible to divers.

The heavy rainfall turns the mountains into myriad waterfalls and streams. The runoff is sufficient to form a nearly permanent layer of fresh water some ten to twelve feet thick that lies over the seawater of the fiord. Only rarely do the rains let up enough for this layer to shrink to a few feet. The layer of fresh water persists because it is less dense than seawater and does not mix with it because large waves cannot form in these narrow, protected fiords.

The rainwater picks up almost no silt or mud during its passage through the virgin forest of the park and over the hard granite. Instead, as it percolates downward





through the forest, it leaches dead leaves and twigs and becomes stained yellow-brown with tannin and humic acid. When it reaches the fiord, the fresh water is colored but not cloudy. It resembles lager beer or tea and obscures everything a foot or more from a diver's face.

The surface layer of fresh water acts as a colored lens, allowing only a weak yellow-green light to filter through to the marine realm below. The quantity and quality of the light passing through the upper layer is therefore generally unsuited for photosynthesis. The typical forests of seaweeds found on most temperate shores do not exist here. This allows species normally restricted to dark caves or deep water to flourish on the dimly lit, steep, subtidal rock faces of the fiords.

At breakfast, we plan the first dive of the day. We had been working in teams, diving every three hours throughout the night to watch for spawning activity in our black coral colonies. Because of this tight schedule and a concern for safety, we consulted dive tables and electronic dive computers before planning this morning's descent. We are, after all, several hours from the nearest recompression chamber, even by helicopter. Although the sun is bright and underwater visibility below the freshwater layer will be sixty to eighty feet, we will still need our lights. The incredible water clarity is accompanied by perpetual gloom. We will dive under the vessel to a depth of 160 feet. The dive will be simple: over the side and straight down; past the spawning black coral at forty feet to the maximum depth; collect and photograph new species of soft coral, sea slugs, and feather stars; then slowly ascend past the walls of brachiopods and the twelve-foot-tall black coral colonies with their symbiotic snake stars and perching feather stars; and finally back through the freshwater layer to the surface.

After performing predive buddy checks and grabbing cameras, collecting bags and

Darryl Torckler



A jock steward fish in Bradshaw Sound, left. A leatherjacket, below, feasts on the eggs of spawning black corals. When spawning, the polyps on the branches, which are normally small and white, swell and turn salmon pink.

Roger V. Grace; Hedgehog House



underwater lights, we brace ourselves for hitting the water. The surface layer not only will have poor visibility, it will also be several degrees colder than the seawater below, since it includes snowmelt. Curiously enough, the rain during the past week has not increased the depth of the fresh water; the layer flows like a river atop the seawater until it reaches the mouth of the fiord and gradually mixes with the waters of the Tasman Sea. At a depth of twelve feet, we pass through the shimmering interface between fresh and salt water and break into crystal clear, relatively warm seawater. The steep rock face descends into the blackness below.

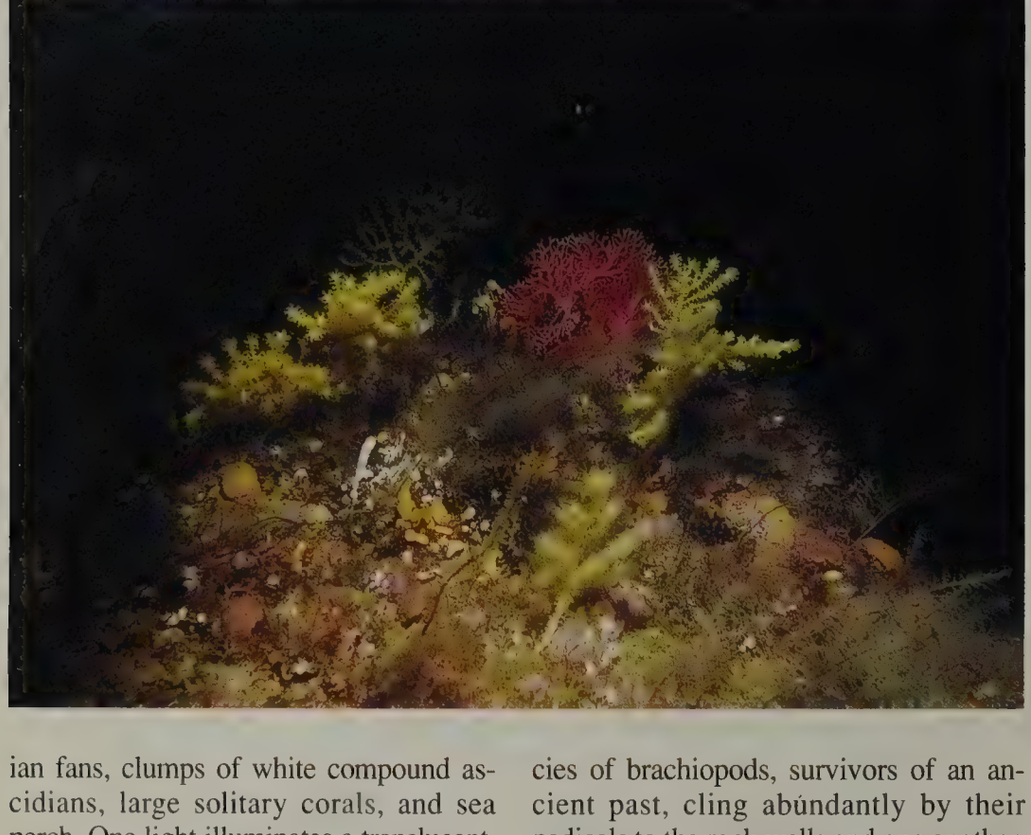
On the descent, we pause briefly on a small ledge at forty feet to inspect a female black coral colony. The small, normally white polyps on the coral's branches have become swollen and turned salmon pink, indicating that this colony is ready to spawn. No one has ever reported on the reproduction of black coral, so with hopes of catching them in the act, we suspend a plankton net over the colony to collect spawned eggs or larvae. For a week, we have been checking the funnellike net and its collection jar, and we discovered that both eggs and larvae are released at dusk and dawn about the time of the full moon. One thing we have not found, however, is male coral polyps. Despite microscopic examination of hundreds of polyps from colonies all over the fiords we have not found a single male. We could have missed them, but it is also possible that the female polyps were reproducing by parthenogenesis, that is, producing viable eggs without male fertilization.

On this morning the jar and net are empty, so we glide over the ledge and descend along the nearly vertical face. Silhouettes of large black coral colonies appear ghostly white against a serene backdrop of emerald green provided by the filtered sunshine. We leave our lights off for as long as possible, so that in the gloom we can see the faint flickering of bioluminescence.

At 130 feet, a cleft about thirty feet wide in the rock face has filled with sand and shell gravel. Protruding from this soft bottom is a field of gently swaying and twisting sea pens, each about eighteen inches tall. A gentle stroke causes each eight-armed polyp to emit a brief burst of blue bioluminescence, momentarily turning the sea pen into a miniature Christmas tree in the very dim light. The rock face once again slopes steeply away below the sand slope, past unknown habitats until it reaches the muddy floor of the fiord almost 1,000 feet below us. Only one brief submersible dive with the crew of the *Calypso* and a few remotely operated vehicle observations have provided any information on the rock walls below normal depths for scuba diving.

We level off at 160 feet and cruise slowly along a relatively barren rock face. The dominant animals are yellow gorgon-

At a depth of sixty feet, a community of invertebrate animals flourishes on a rock shelf in Doubtful Sound.
Ken Grange; Hedgehog House





ian fans, clumps of white compound ascidians, large solitary corals, and sea perch. One light illuminates a translucent, white soft coral colony, standing about a foot tall and shaped like a cauliflower. This is an unknown species, so we photograph the colony and carefully collect it for description by specialists. Another light falls on a bowl-shaped, yellow sponge with a flat sievelike top. With our brains slightly affected by nitrogen narcosis, we struggle to identify it. Gradually we realize this is a glass sponge, previously recorded only from depths of more than 300 feet on the continental shelf—yet another deepwater species that finds a safe haven in these fiords.

As we begin to ascend, we find small patches of sand that almost invariably support large tube-building anemones. The long tentacles stretch lazily out into the gentle current, and often one rapidly coils and spirals downward toward the mouth after ensnaring small planktonic shrimp. Back up at sixty feet we search for a side-gilled sea slug that was seen on a previous trip, but have no luck. Instead, we check on another experiment we set up a few days before. In this environment, four species of brachiopods, survivors of an ancient past, cling abundantly by their pedicels to the rock walls and one another. Elsewhere in the world these animals have all but disappeared, despite their dominance in ancient seas. Why should they be so abundant here? Brachiopods are distinguished from bivalve mollusks internally by their double-spiraled lophophore, which serves both as a respiratory and food-collecting organ.

We suspect they compete poorly against the more reproductively aggressive mollusks, such as mussels, and are now more or less restricted to refuges where perhaps food is too limited to support their competitors. To test this idea, we transplanted mussels from shallow water down to the brachiopod habitat and brachiopods up to the mussel habitat. Some of the transplants are protected from predators with cages, while others have to fend for themselves. We hope to have the results in twelve months, which, combined with other research, will determine whether a lack of food or increased predation keeps the mussels out of this habitat and allows the brachiopods to be successful.

At depths of about fifty feet, the cliffs are dominated by large colonies of the black coral *Antipathes fiordensis*. More than 7 million colonies of this protected species live in depths of 100 feet or less throughout the New Zealand fiords. This is the largest and shallowest population of black corals known. Living black corals can be white, gray, green, orange, or even bright yellow, but never black. The term refers to the skeleton secreted by the tiny

A snake star rests tightly coiled around the branches of a black coral. Snake stars, which are distant relatives of starfish, often remain on the same perch year after year.
Darryl Torckler



polyps, the individuals that make up the colony. Since these polyps are easily abraded and most black corals were originally collected by dredge, the description was based purely on the skeleton.

Black corals are not even "true" corals, since they are anatomically distinct and do not have a skeleton of calcium carbonate. Instead, the semiprecious, ebonylike material in the skeleton is a protein reinforced with chitin fibers similar to insect cuticle. The protein is yellow-brown, but in multiple layers it appears jet black. The treelike skeleton, which has no roots, is cemented to the submarine cliffs and provides the coral colony with a rigid and resilient support. When heated, this material can be twisted and bent, yet when cool it is hard enough to fashion and polish into jewelry and curios.

Black corals, or Antipatharia, occur in all oceans, in depths ranging from shallow water to several thousand feet. About 150 species are recognized, the majority of which are found in tropical and subtropical oceans deeper than 300 feet. Even so, only a few specialists worldwide can identify more than a handful of species. Until recently our ecological knowledge of black corals was limited to a few studies



on populations in Hawaii, Trinidad, and Jamaica and a few isolated submersible observations. Because most black corals live at depths greater than 100 feet, the dives needed to conduct detailed investigations and experiments are difficult and dangerous. In the New Zealand fiords, however, black coral grows in water as shallow as 15 feet. Their accessibility, prominence, and potential for attracting recreational divers and associated tourism provided the impetus for an international research program. Slowly, the private lives of these little-known organisms have begun to unfold.

We began with an apparently simple task: to measure growth rates in colonies of Fiordland black coral. X-rays of branches showed clear growth rings, similar to those of trees, but we had no way of knowing whether these were annual or laid down in connection with such other events as food availability, reproduction, cold or warm periods, or catastrophic storms. After almost seven years of research, we have growth rate data from tagged colonies, size distributions, and chemical markers of the growth rings in the skeleton, all of which indicate that the rings are annual and that most colonies grow less than an inch per year. This is at least three times slower than a similar species studied in Hawaii.

One colony directly in front of us is huge, fifteen feet tall from base to the top branches, and the actual length of the main, crooked branch is more than eighteen feet, indicating that this colony might be well over 200 years old. Some of the very largest colonies we measured in one of the other fiords must be 300 years old or more and may have been living when New Zealand fiords were first charted by Capt. James Cook in 1773.

The largest colonies in any one area almost always occur along sharp ridges or on corners of rock faces. At first we assumed this reflected an increased planktonic food supply sweeping past these promontories. But the growth rings in these specimens were no wider than those from more sheltered sites, suggesting that they had the same growth rates. They were simply older.

The increased survival of black corals along ridges turned out to be linked to the topography of the forest above. The thin veneer of soil on the steep mountain sides cannot support the oldest trees, so at some stage entire strips of forest slide into the fiord, bringing with them rocks and silt. Such slides are frequently triggered by earthquakes, which arise along the nearby plate boundary straddled by this part of New Zealand. The resultant landslide can occasionally clear a submarine swath up to 500 feet wide. Because rocks and forest debris tend to tumble to the sides, those black coral colonies perched along submerged ridge lines are spared. We have used this knowledge many times to find the largest colonies. We simply find a patch of forest with mature trees that shows no landslide scars and dive there.

As we continue our ascent along the submarine cliff, just off to our right a large trunk of a podocarp lies at an angle across a small rock ledge. This tree fell only a year ago. We remember because it carried away twenty-one tagged black coral colonies, part of our growth rate experi-

Roger V. Grace; Hedgehog House

At night, snake stars, left, feed on the tiny bits of food trapped by the black coral polyps. After gaining a foothold on a branch of black coral, a soft coral, below, is contained by the special black coral polyps with long, spaghettilike stinging tentacles.

Ken Grange and Walter Goldberg



ments. Within a few weeks, small white urchins had crawled over it, and now this trunk, originally a foot in diameter, was almost entirely rasped away. The forest above these fiords is an integral part of the marine food web since *in situ* plant production by phytoplankton and seaweeds is severely limited in these dim waters. Instinctively, we look up, remember the large beech tree the research vessel is tied to, and hope the wind has stayed calm.

Most of the black coral colonies around us are healthy. All the branches are covered with small white polyps, each with six tentacles surrounding a mouth in the center. Tentacles are loaded with batteries of specialized cells containing spirocysts, whose prime function is to capture tiny plankton. The spirocysts accomplish this by ejecting sticky threads. The polyps then reel the immobilized prey into their mouths. We had spent many minutes over the past few nights hovering near these colonies with our lights off, watching plankton being caught. One particular species of copepod, a tiny crustacean, emits a burst of light when captured. At times, a whole black coral colony may twinkle as hundreds of these small organisms are caught. Sights like these make getting out of bed in the middle of the night during cold and heavy rain worthwhile.

In some places along a few branches strange polyps appear with considerably elongated tentacles. These defensive tentacles grow in response to invading soft corals, which grow on the black coral. (Because soft coral larvae would normally be consumed upon contact with healthy black coral, they can only gain a foothold on the black coral's skeleton after it has been exposed, owing to an injury.) These defensive fighter, or sweeper, tentacles have an impressive battery of powerful stinging cells, the nematocysts. Their task is to keep faster-growing, would-be invading species from overgrowing the colony.

Reluctantly, we leave the forest of black corals and swim up to thirty feet to meet an old friend, a smaller black coral colony, three-quarters dead but with one healthy side supporting a dark red snake star. A particularly flexible type of brittle star, this species of snake star lives only on black corals. Throughout the day the five arms, which may be up to eighteen inches long, remain tightly coiled with half-hitches around the coral branches. At night or during exceptionally dark days, the arms uncoil and continually wave about through the coral branches and the surrounding water. Previously, marine biologists presumed that these brittle stars used the black coral colonies as convenient perches from which to extend their arms into the water to catch plankton. But if this were true, we wondered, why did we never find them on sunken trees or dead colonies? Invariably, they are found only on healthy branches of the colonies. We also knew they did not move because, for more than six years, we had repeatedly observed the same individuals, distinguished by their color patterns, on the same branches, with no apparent damage to the underlying polyps.

Experiments we conducted at night showed that these snake stars steal the plankton caught by the coral. But why does the host put up with this? Our answer came after one of the landslides. Those corals with snake stars survived the smothering effects of silt better than those without. One night, we carefully removed a snake star from a healthy coral and transplanted it to the colony that we were now examining. The colony had been covered by silt and was producing mucus in an attempt to wash the silt away. One month after the transplant, the coral polyps around the snake star were healthy and free of sediment. The cleared area corresponded to the area swept by the arms during nighttime feeding. Three years later, the area around the snake star was still healthy, whereas the rest of the colony had died and become overgrown by bryozoans, sponges, and soft corals. The black corals put up with some of their food being stolen in return for increased survival. Such symbiotic relationships are especially important to a species that may live for centuries, unable to move in response to unfavorable changes in its environment.

The scientific term for black coral, Antipatharia, is derived from the Greek

Thirty feet below the surface of Caswell Sound, a biscuit star rests on a bed of colonial sea squirts.
Darryl Torckler

words *anti* (against) and *pathos* (suffering). Many cultures throughout history have used the skeleton for a variety of medicinal and mystical purposes. Black coral may no longer be considered sacred by most cultures, but living colonies certainly command a special respect. Colonies often present themselves to sport divers as ghostly trees along steep drop-offs in currents, at the very edge of safe diving depths where their beauty is enhanced by nitrogen narcosis. Too often, these corals have been exploited for commercial purposes, resulting in the depletion of most populations within diving depths. Black corals are now listed in the Convention for the International Trade in Endangered Species (CITES). They are completely protected in New Zealand.

A sudden drop in temperature reminds us we are back in the surface layer. We drop down a few inches and use up the remainder of our air in the relative comfort of warmer water, watching sea spiders, or pycnogonids, wandering about on mussel shells. Such long legs for such minute bodies. Small labrid fishes dart up into the freshwater layer to pick a barnacle, mussel, or piece of sea lettuce and swim back to the safety of the seawater. A line of predatory starfish, and little else, hovers just below the sharp interface between the two layers. These roving bands wait for slight changes in the thickness of the freshwater layer; when the layer thins, they can move up and feed on the blue mussels. When the rain begins to fall again, the starfish will retire below the freshwater layer because they are unable to withstand even the brackish water at the interface, as can the mussels. After the rain of the past week we wonder how hungry they are.

We make one more dive to retrieve the plankton net over the female coral before we sail back to a wharf twenty miles farther up the fiord. From there we will take a four-wheel-drive vehicle over the mountain pass and a ferry across New Zealand's deepest lake before we reach the nearest small town. As we pack the gear, the sky darkens and clouds gather. One clear morning in seven is about right. □





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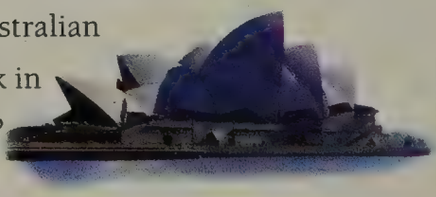
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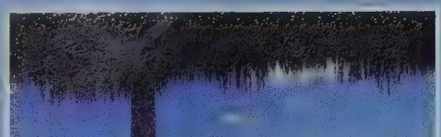


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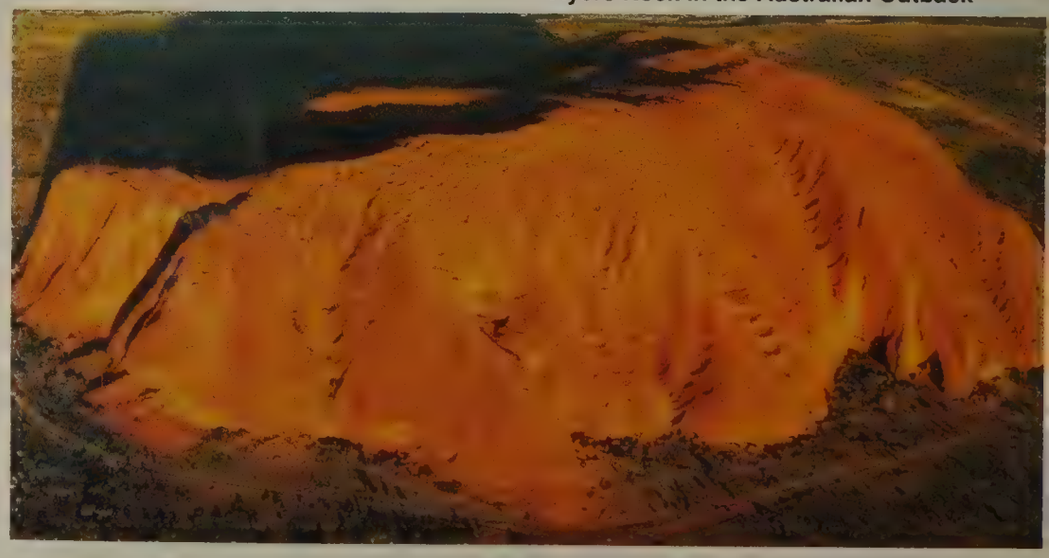
From the rumpled roof of Ayers Rock, the arid red earth stretches seemingly forever, its horizon broken only by the dome-like humps of the Olgas. This is the Northern Territory, twice the size of Texas, a world immensely remote, empty, and old. It is a part of the vastness known, in that incomparable Australian slang, as the Outback.

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Ayers Rock in the Australian Outback



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Richer than rajahs in history, art, and architecture, India can produce cultural indigestion. Begin with a small bite, but a superlative one: the Ajanta and Ellora caves, about 250 miles east of Bombay.

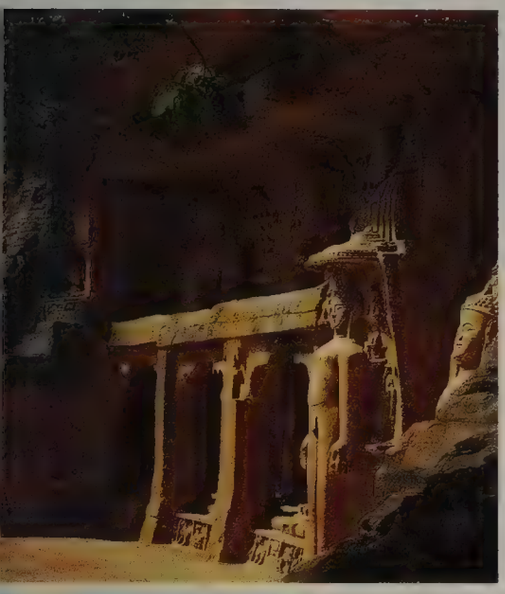
These hand-hewn "caves" (they deserve a more descriptive term) may have a few equals in man-made miracles — Egypt's pyramids, possibly, or Abu Simbel; Petra in Jordan; Machu Picchu in Peru — but no superiors. Here on the Deccan Plateau, artists carved in stone temples, shrines, Hindu gods and goddesses, figures of Buddha, public halls, courtyards, streets — all from solid rock.

Of all the caves (29 at Ajanta, 34 at Ellora), Kailasa Temple at Ellora is so dizzying in its conception, not to mention its execution, that you may fall on your knees to catch your breath. It alone is worth a trip to India.

To appreciate the achievements of Ajanta and Ellora, the traveler requires

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The Jain sculptures at Gwalior Fort in Central India

used along the way. Throughout the entire trip a traveler's every need is attended to and even the most minute of details is carefully planned in advance. The tours are small, creating a true learning vacation while traveling with like-minded individuals. Swan Hellenic is also well known for its cruises on the Nile, Mediterranean, Aegean, Red and Black Seas, as well as Europe's scenic rivers.

Indonesia

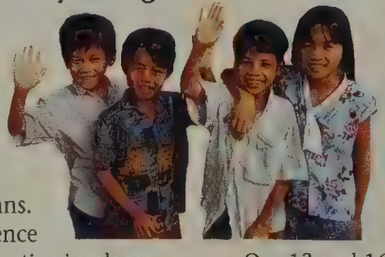
Deep in the rich, green heart of central Java — a region of still-smoking volcanoes, manicured rice paddies, and crowded villages where every day is market day — there rises one of Indonesia's greatest artistic and historical treasures, the world's largest Buddhist temple, Borobudur.

The massive pile constructed in the eighth century by the labor of thousands of designers, laborers, and sculptors is hundreds of years older than Cambodia's better-known Angkor Wat. Despite its

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Be prepared to experience the new Vietnamese perspective in places with familiar names. Hanoi. The home of many national monuments, Hanoi has a native market that is a good example of the enormous energy of a people who are rebuilding their lives. **Marvel** at the park which contains the Lake of the Sword, right in the middle of the city. Hue. Formerly the Imperial City, Hue is surrounded by summer palaces and burial grounds of former kings. Saigon. Where the jungle comes right down to the river and little villages pepper the tributaries. Suddenly, sailing up the river, you're at the dock in the center of a city that has been called "the Paris of the East".

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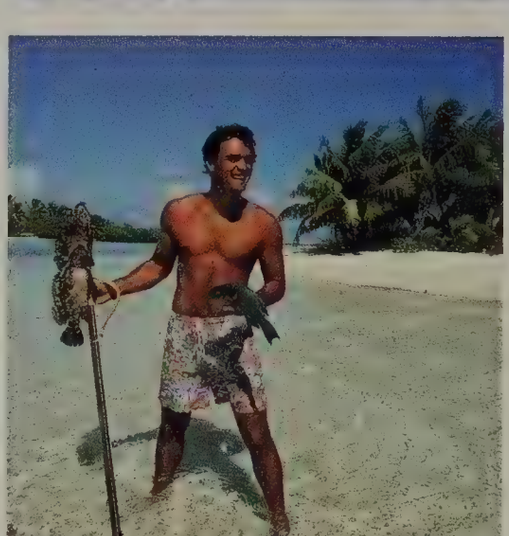
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Ancient carvings in Borobudur, the world's largest Buddhist temple, in Indonesia



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Spear Fishing in the Blue Lagoon at Rangiroa in French Polynesia

magnificence, the temple was abandoned only shortly after its completion when the center of Buddhism shifted away. It rested, forgotten, for a thousand years under coats of lava until rediscovery by Sir Stamford Raffles (the founder of Singapore), in the 1800s.

Excavated at the beginning of the 20th century, the masterwork began to collapse under it own weight and the ravages of a tropical climate. Following a decade of work with the aid of the United Nations, it once again stuns the imagination.

Indonesia's best-known islands — Java, Sumatra, and Bali — are only three among the 13,677 in the world's largest archipelago. They are most comfortably visited on a custom-arranged trip conducted by experts in the region, such as those sponsored by Bolder Adventures, specialists in Southeast Asia.

Malaysia

As green as an emerald, as fragrant as a breeze off the Straits of Malacca, Malaysia (about the size of New Mexico) is an exotic blend of cultures: Malay, Chinese, and Indian with a touch of British from the days of Empire. Geographically it consists of Peninsular Malaysia, dangling off the south tip of Thailand, and the states of Sabah and Sarawak on Borneo, (the world's third largest island).

Malaysia has many alluring aspects: great cuisines, splendid arts and festivals, and the handsomest capital city in the East, Kuala Lumpur.

Nature is the artist here, its palette producing jungles of green a hundred million years deep, sands of a white talcum softness, flowers that explode in a galaxy of 15,000 species, including the world's largest flower, the rafflesia.

Squeezed into this small space is a garden of diversity: rain forests home to a wealth of wildlife (Taman Negara is the national virgin reserve); stretches of lonely beaches along the East Coast; high mountain plateaus with retreats suggestive of the British hill stations in India, (where fireplaces and hot toddies are de rigueur), and the granite dome of Sabah's Mount Kinabalu. Its 13,455-foot heights should be scaled only by energetic climbers.



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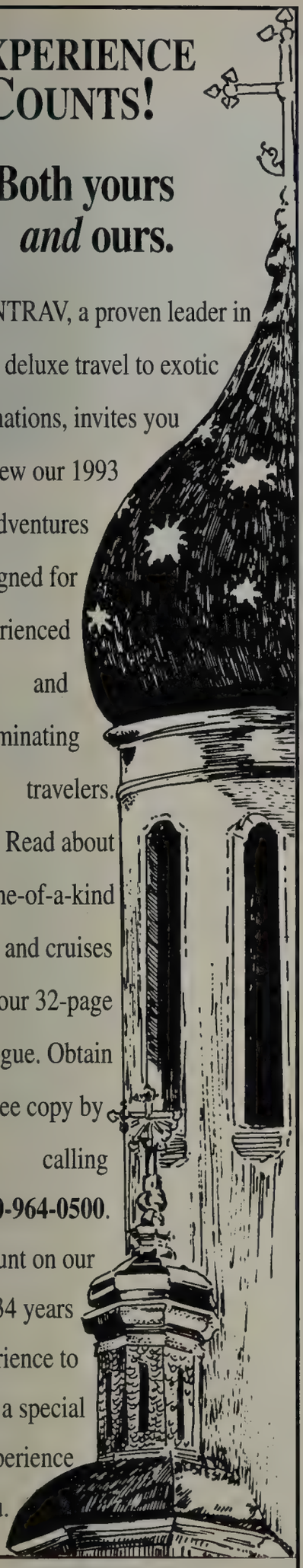
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Morocco

So much is mysterious in Morocco that the visitor seems always to be strolling in a dream world, a world more likely to be staged by Hollywood than by reality.

All Morocco's surreal qualities emerge in the city of Fez, "where all is Eden or a wilderness," in the words of Lord Byron. Deep in the twisting streets of the medina, where leather workers labor in a scene out of Dante's underworld, you become lost in a swirl of colors never before seen, of smells indescribably odd, you begin to feel as if you have entered a world beyond ours and may never find your way out.

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Local Tribesmen, New Guinea Highlands

New Zealand

Deep at the "bottom" of the globe, between the South Pacific and the Tasman Sea, float the North and South Islands of New Zealand. Geologically ancient (500-600 million years) it was the last major land mass (besides Antarctica) to be reached by man. (The Polynesians, Maoris, arrived about 1,200 years ago; Europeans not until the mid-18th century.)

But here, as in so much of the Pacific, nature reigns particularly powerfully on South Island. Lesser known than Mount Cook (Aorangi, the Cloud Piercer) is Fiordland, the country's largest national park which is almost three million acres.

Deep on the southwestern coast, Lakes Te Anau and Manapouri lie cold and clear between sheer-sided cliffs and wild, deep valleys. It's a land of legends, including that of the Lost Tribe of Manapouri. At least ten fiords cut to the sea, including Dusky Sound, discovered by Captain James Cook in 1770. The most beautiful is Milford Sound, much of its spectacular scenery sliced by the Milford Track, the "finest walk in the world." It is open from November to April.

The cultures of both the British and the Maoris have left their varied impressions: the Maori especially in the Auckland Museum and the British in entire towns such as Christchurch.

Papua New Guinea

Every moment one spends in Papua New Guinea is an adventure. Almost nothing seems familiar; this may not even be the 20th century.

Papua New Guinea, a country slightly larger than California, occupies the eastern half of the island of New Guinea. The landscape is often savage and primitive, from swampy plains to ragged, majestic mountains cut by chasms where, flying over in a small plane, one can believe no human ever walked. The rain forests, mangrove swamps and savannah grasslands can seem absolutely eerie.

In Papua New Guinea it is the presence of the indigenous peoples that seduces the imagination. Many of the hundreds of tribes live in virtual isolation, speaking mutually unintelligible languages. Western civilization is an upstart; as recently as 1937, many of the people of the Highlands saw their first steel tool, their first wheel, and their first white man.

Today, tribes that once battled till death compete in "singsings," festivals of chants and dances performed in gorgeous costumes. Thousands of warriors, glistening with pig grease and charcoal, their heads bedecked with feathers, dance out their dreams and legends. Major singsings are held in August and September in either Goroka or Mt. Hagen.

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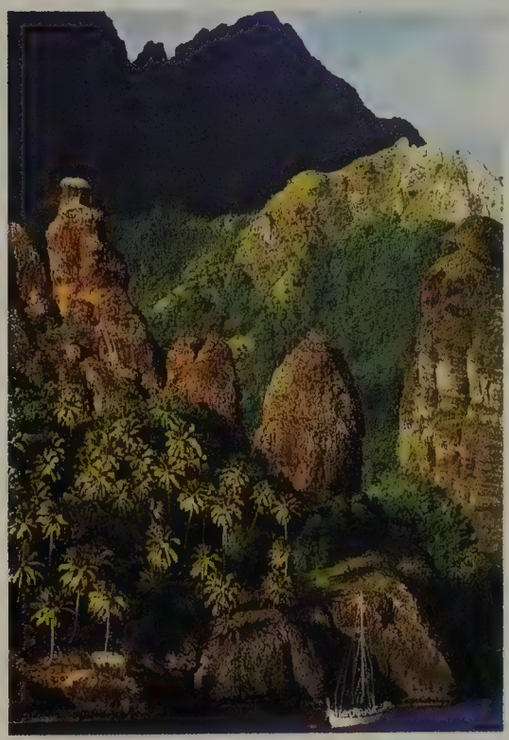
Tahiti

Tahiti sings a siren song of tropical beauty (and beauties) and has since it was "discovered" by Captain James Cook in 1769. Herman Melville and Paul Gauguin were entranced with this island paradise, and even Charles Darwin was forced out of his scientific stoicism to wax enthusiastic about its unique characteristics.

Tahiti is only one of the Society Islands of French Polynesia Overseas Territory, a group of 130 widely scattered islands in five archipelagos in the South Pacific. Because it is the best known and the administrative center, its name has become synonymous with the entire area.

More than half the population of the region lives in Tahiti and its only city, Papeete. In recent years, several other of the Societies have become popular with wanderers: Moorea, Bora-Bora, Huahine, Raiatea, and even little Maupiti, where the few and friendly inhabitants give occasional beach parties for the resident tupapa'u (ghosts).

People who really want to be alone seek sun, sand, and sea in the Marquesas, Tuamotus, Gambier, and Austral islands.



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At anchor at the Bay of the Virgins, Fatu Hiva, Marquesa Islands

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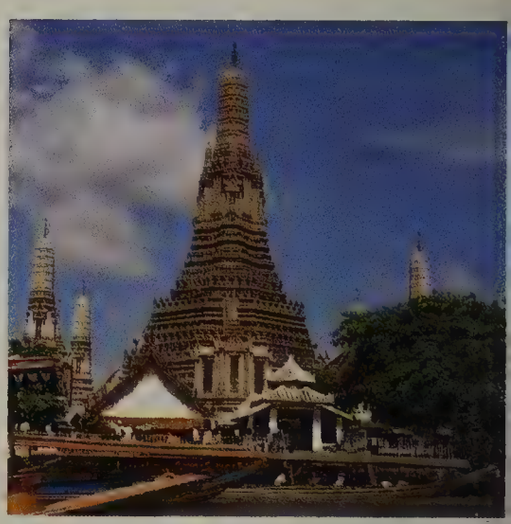
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Thailand

The "modern" kingdom of the Thais (Prathet Thai) had its cultural beginnings in Sukhothai, a city founded in 1238. It endured only two centuries but left a legacy of architecture that remains the national style even today, most apparent in the elegant, upturning wat (temple) roofs.

Thailand is the only country in Southeast Asia that was never taken over by a European power, and to a greater degree than any of its neighbors, it has maintained its traditional art and architecture.

Bangkok is studded with magnificent temples, shrines, and palaces, but yet is so contemporary it fails to transmit a sure sense of antique Thailand.



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The Temple of Dawn on Chao Phraya River, Bangkok

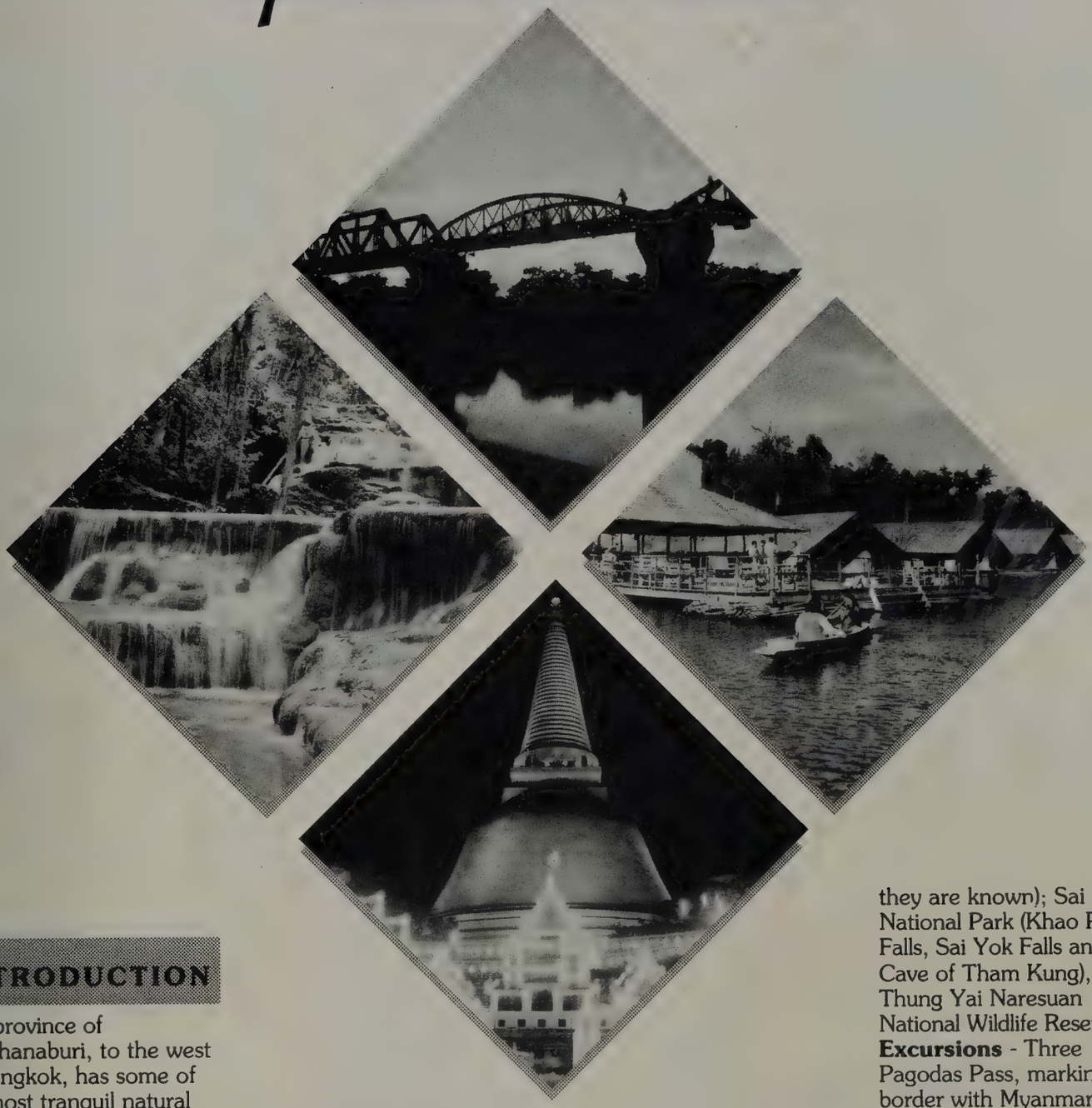
That can be discovered in the country town of Ayuthaya, only 53 miles north of Bangkok. In the 17th century, before being devastated by the Burmese, it was a glittering city that surpassed in style and size both London and Paris. Today, it lies largely in ruins (but what stately, imposing ones!). To skip Ayuthaya is to miss out on one of the historical moments that created today's Thailand.

The earth is inexhaustible. As Lord Chesterfield wrote to his son more than two centuries ago, "The world is a country which nobody ever yet knew by description; one must travel through it one's self to be acquainted with it."

EXOTIC Thailand

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Kanchanaburi



INTRODUCTION

The province of Kanchanaburi, to the west of Bangkok, has some of the most tranquil natural sights in Thailand; and one of the most infamous made by man: The Bridge on the River Kwai.

The area is blessed with forests, caves and waterfalls, including the mighty Erawan Falls, and is home to the world's tallest Buddhist monument at Nakhon Pathom.

ATTRACTIONS

Sights - The infamous 'Bridge on the River Kwai', built by allied POWs during World War II and made famous by the film of the same name; Allied War Cemetery (the resting place of 6,982 Allied soldiers) and War Museum.
Temples - Phutthamonthon, Phra Pathom Chedi, the world's tallest Buddhist monument at Nakhon Pathom.
National Parks - Erawan National Park (Erawan Falls or 'Elephant Falls' as they are known); Sai Yok National Park (Khao Phang Falls, Sai Yok Falls and the Cave of Tham Kung), Thung Yai Naresuan National Wildlife Reserve.
Excursions - Three Pagodas Pass, marking the border with Myanmar.

HOW TO GET THERE

Kanchanaburi town, in the province of the same name, is 122 km northwest of Bangkok near the border with Myanmar (Burma). It can be reached by hire car, coach or rail.







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What's in a Name?

By Gail S. Cleere

On March 27, about an hour after sunset, a lovely scene takes place in the west as the five-day-old crescent moon passes just below the Seven Sisters, known to the Greeks as the Pleiades, perhaps deriving from the Greek *pleō,* meaning "sail." The heliacal rising of this striking group of stars, that is, the time of year that they rise in the morning before the sun, signaled the start of the Greek navigation season. The stars are still called the Sailor's Stars in England and Germany.

Best observed in the winter sky, the Pleiades has no bright stars, but it is so compact that the effect is astonishing: "like a swarm of fireflies tangled in a silver braid," according to Lord Tennyson in his poem *Locksley Hall.* The stars have attracted the attention of other cultures, which also named them; they are known as the Needleworkers in China, the Seven Little Nanny Goats in parts of Spain, the Six Wives Who Ate Onions (cast out of their tents into the heavens by offended husbands) to one American Indian tribe, and the Lost Children to another.

Marveling at the beauty and immensity of the night sky, you can be sure that all the stars you see, and a large number of those you don't, have had their positions, brightness, masses, and spectral types studied and cataloged by now. And you might assume that all these stars and star groups, not to mention all those other celestial objects, have names—like the Pleiades. But you would be only half right.

Some of the brightest stars, known since antiquity, have retained their ancient names. Many of these names were passed to us from the Arabs, whose desert life (and clear skies) necessarily made them very familiar with the stars. In his 1899 classic, *Star Names and Their Meanings,* Richard Hinkley Allen tells us that to understand the names of antiquity we must look to the desert, "where the stars would be as much required and relied upon for guidance as on the trackless ocean." The fourteenth-century Sultan Ilderim is quoted as saying, "Thou canst not know how much we Arabs depend upon the stars. We borrow their names in gratitude, and give them love."

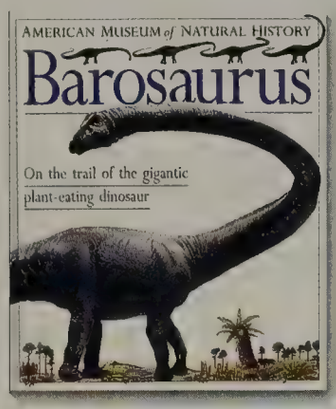
The ancient Arabs named stars for shepherds and herdsmen, horses and their trappings, cattle, camels, sheep and goats, birds and reptiles, lions, tents, ornaments, and household goods. We also find ancient names that mean The Trusted One, The Lofty One, The Unfortunate, or The Solitary One. Many of these turn out to be Arab translations of Greek and Roman descriptions.

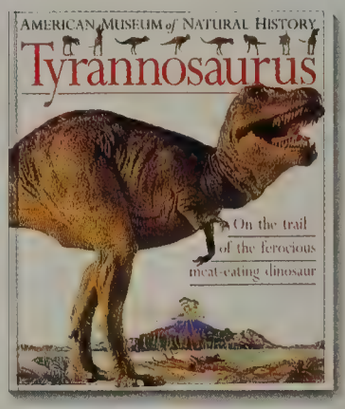
Today, contrary to the claims of those in the lucrative "business" of naming a star for the person of one's choice, no popular names are recognized by the world's astronomers. The naming of the stars and other celestial objects has passed from the storyteller and myth-maker to a select group of astronomers of the International Astronomical Union's (IAU) Commission on Astronomical Names. (Nevertheless, those who run these scams continue to collect money from individuals who hope to be immortalized in the heavens.) Poetry and myth have given way to numbers. As each star is identified, it is given a number according to the catalog into which it is being entered. But the old names given the bright stars of antiquity are happily r tained—and are still used, in addition their numbers.

In 1603, Johann Bayer, a Germa lawyer and amateur astronomer, intr duced another way of identifying the sta by using a letter of the Greek alphabet conjunction with the star's home conste lation name in Latin. In a number of case the brightest star in the constellation named Alpha, the next brightest, Beta, a so on. Thus Regulus, the brightest star Leo, would be called Alpha Leonis, a Denebola, the second brightest, would Beta Leonis. Because only two dozen of constellation's stars could be named th way, stellar catalogs were created, wi each star receiving a number. The mi nineteenth-century German catalog, *Bo ner Durchmusterung,* listed about 320,0 stars designated by their BD number. the 1920s, the Henry Draper catalog liste stars by their HD number. Over 100 no stellar objects were listed by the eigh eenth-century astronomer Charles Messi and are referred to as Messier objec (M42, for example, is the Great Nebula Orion). Later, in the nineteenth and twe tieth centuries, thousands more were liste in the *New General Catalog* of astronom cal objects.

The last major planet to be discovere Pluto in 1930, kept with tradition and wa assigned a name from mythology. So we many of the most recently discovere moons, or natural satellites of the out planets. But the minor planets, such a those orbiting the sun in a belt betwee Mars and Jupiter, can be given practicall any name the discoverer wishes, withi

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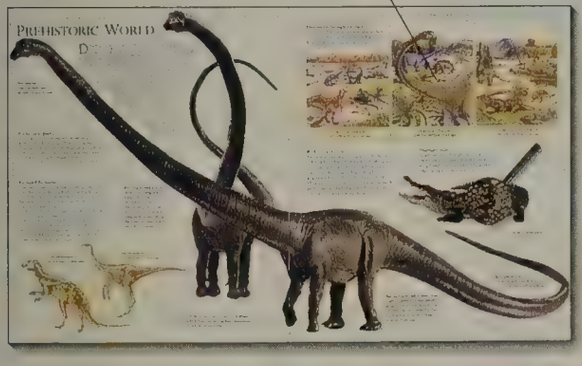
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reason, subject to approval by the IAU's special commission. Thus there are asteroids named for illustrious personae (living and dead), countries, cities and townships, plants, universities, electric calculators, sweets, social clubs, musical plays, and shipping lines. Recently an asteroid was named after a group of winemakers in California (the Rhonerangers).

Comets, on the other hand, are the only astronomical objects allowed to be named for their discoverers—hence a dedicated observer's one chance at immortality. Once in a while NASA looks for help in naming the features on astronomical objects. When the Magellan spacecraft first began mapping Venus, scientists found they needed to come up with some 4,000 new names. They appealed to the general public and were quickly overwhelmed with suggestions. Many of Venus' features had been named for the goddesses of ancient religions and cultures, but the craters and volcanic vents were being named for actual women. The rules noted that these notable women must have been dead least three years and that they couldn't nineteenth- or twentieth-century milita political, or religious figures. On Mercu many of the craters are named for artis poets, and composers.

The Planets in March

Mercury is hard to spot this month mid-northern latitude observers, reachi inferior conjunction (passing between earth and the sun) on March 9. For the r of the month, it will be low in the morni sky.

Venus dazzles us by maintaining greatest brilliancy of the year for most the month (–4.6 magnitude—no oth planet reaches this brightness). At the b ginning of the month, Venus is visib high in the west at sunset, but, as Mar progresses, this brilliant planet dro closer and closer to the horizon. On the l few days of the month, Venus will be vi ble in both evening twilight and morni twilight, a phenomenon that occurs or



"Looks like a black hole to me, but I've never seen one so close to our galaxy."

ce every eight years. Viewed with the l of a telescope, or even binoculars, nus appears as a crescent that grows nner all month.

Mars maintains a planetary outpost gh in the constellation Gemini, nearing meridian (a north–south line stretching ross the sky from horizon to horizon) out sundown and setting more than two urs past midnight. On the 3d, and again the 31st, the waxing first-quarter moon ys a call just to the south of Mars. Watch ars get closer to Gemini's bright stars ıstor and Pollux during the month.

Jupiter rises just after sunset and is vis- e for the rest of the night throughout the onth. This gas giant lurks against the ckground of Virgo and is easily located looking just above Virgo's bright star ica (Jupiter will be by far the brighter of e two). Just before dawn on the 10th, ok for the waning gibbous moon passing st below Jupiter.

Saturn is lost in the solar glare, staying o close to the sun's eastern edge to be sible this month. Early in April, Saturn ll make an entrance in predawn skies.

Uranus and **Neptune** continue to cling gether (Neptune above Uranus) just to e east of Sagittarius, simultaneously vis- e within a moderate-sized telescope's ld—the only time in our lives that this ll occur. Both can be found in predawn ies, with the waning crescent moon ssing quite close by on the morning of e 17th.

Pluto rises shortly before midnight, not from the +3.5 magnitude star Mu Ser- ntis in the constellation Serpens. An ght-inch telescope and some accurate r charts are needed to see Pluto under ry dark skies as it approaches opposi- n in May.

The **Moon** reaches first quarter on the t at 10:46 A.M., EST; is full on the 8th at 46 A.M., EST; reaches last-quarter at :16 P.M., EST on the 14th; is new on the d at 2:14 A.M., EST; and reaches first- arter again on March 30 at 11:10 P.M., ST. (The same lunar phase repeating in a onth is not very common, but does cur.)

The vernal equinox can be seen on the th at 9:41 A.M., EST, marking the begin- ng of spring in the Northern Hemi- here.

ail S. Cleere writes on popular astron- ny and is a founding member of the ternational Dark Sky Association, an ganization dedicated to preserving the ies for astronomy.

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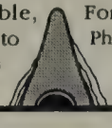
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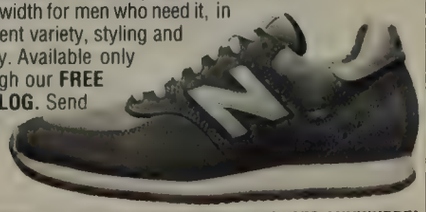


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No Chance

Any way you look at it, smoke gets in your eyes

by Roger L. Welsch

The Hubbell telescope turned its astigmatic eye, I read in the newspaper the other day, in the general direction of somewhere else and spotted evidence that two galaxies recently collided. I don't know about you, but I can't help but wonder who's driving. I can understand running over a thirteen-striped ground squirrel on the highway now and then, but how can you miss a galaxy coming at you on a clear night?

We are dealing here, I think, with averages and odds, the margin, chances, the spread. Everything I know about gambling—poker, the stock market, or colliding galaxies—suggests I should put my money under the mattress. As far as I can tell, most of the stuff we think of as being a matter of chance is actually a sure thing. Horse races and lotteries are set up by law to pay out less than comes in. Right up front they tell you that you are darn near guaranteed to lose your it-is-to-laugh investment. Dwaine, our mailman, brags about the time he went to Las Vegas (he calls it "Lost Wages") and won nearly five hundred dollars. He admits, however, that he had to spend a thousand to do it.

Same thing in the galactic lottery. What are the chances of a huge meteor or comet striking the earth and destroying all life on it? Now, think about it. Given a squillion years and a squillion meteors and comets and the kind of steering that allows one galaxy to sideswipe another, the chances are, roughly, 100.000 percent, give or take another googol of zeros.

Same thing with marriage, speaking of intergalactic collisions. What are the chances of a marriage having a happy conclusion? 00.000 percent, that's what. Forgetting for the moment the peculiar convention of annulment, in which four or five grown-ups look at each other, shuffle some papers, and conclude that what happened didn't really happen, all American marriages end in death or divorce, with some question about which is worse.

The premise in gambling is that the odds are close to fifty-fifty, or maybe, now and then, on Friday the twelfth and when you're wearing the right socks, just a tad in your favor. Well, that's wrong. Things are a lot more certain than what they appear to be, and almost never in your favor. (If you think I'm being a Gloomy Gus, go to your local bank with that letter from Ed McMahon saying you're about to win ten million dollars, and try using it for collateral to take out a loan.)

Campfires. I have spent a lot of my life sitting at campfires. You'd think that over the long run, smoke would blow away from my face about half the time and into it about half the time. Well, no, that's not right either. Figuring I'm not a total dufus, I should have the sense part of the time to move somewhere around the fire where I can avoid the smoke, and besides, there are four quadrants, so I should be in the smoke only 25 percent of the time, even if I pay no attention at all to which way the wind is blowing.

Ha! If you sit downwind, smoke blows in your face, and if you sit upwind, the wind comes around you in little vortexes and pulls the smoke right up the front of your overalls, right into your face. If you sit at right angles to the wind blowing across a campfire, smoke still blows in your face, for reasons not yet explained by science. So no matter where you sit around a campfire, the odds are 100 percent that smoke will blow in your face. (Millennia ago, when I was in the Boy Scouts, v built little wooden baffles upwind of o fires to serve as an open chimney, but I' too smart for that now.)

As a teacher, I used to ride my bike the university, and my knees and I oft wondered why we were always going u wind. I don't know for sure but I suppos was going ten miles an hour (hey, my bi had fat tires, I was no longer thirty-som thing, and it was early in the morning late in the afternoon, so you can laugh ten MPH but that was pretty good, consi ering). And if the head wind was five mil an hour, then I had a relative head wind fifteen miles an hour, right?

I think that most days the wind shift so I encountered the same handicap co ing home, but assuming that the wi stayed constant during the day, I bik home at ten miles an hour with a five-mil an-hour tail wind, which means that I st had a relative head wind of five miles a hour. Everything remaining constant, had a head wind both ways. If I came to nice downhill run and got up to twen miles an hour, then my relative head wi picked up to fifteen miles an hour. Wh kind of justice is that?

I'm a Pollyanna optimist but I a amazed again and again at the faith oth people have in the auspicious nature "the odds." I was once at a concert whe two pianists were playing grand piano You know the scene: The pianos we nested together so the musicians were fac ing each other, flailing away at compl cated harmonies and musical intertwi ings. I turned to my friend and said, "Bo they sure are good." He embraced th human tendency to believe in good karm and responded, "Or awful lucky."

Similarly, a lady friend of mine once ought Mount Rushmore was a natural enomenon. She could deal with the nd carving four human heads in solid ck, but four presidents…almost too uch! I shared her bewilderment then and ll do.

I too have now and then leaned too hard presumptions of good fortune. A few ars ago I was watching a Muhammad i–Leon Spinks bout on television up at ck's Tavern. Knowing a little bit about xing, I expressed my opinion that Ali as blowing the fight because he was cking up. "You don't win the heavy-eight championship of the world back-g up," I said.

Mick Zangretti said, "I think you're rong, Rog. Ali is winning, backing up or t."

"Ha!" I exclaimed, remembering that ick thinks new cars are a good invest-ent, and suggested that if he knew so uch about boxing, maybe he'd like to put me money on the bar. He plunked down enty dollars, I matched it, and then he plained that we were looking at a post-ght rerun. The fight had finished while e were eating pizza an hour earlier, and i got a unanimous decision. I covered yself by saying that I was aware of that t I sure didn't think Spinks would make e same mistakes twice in one night (I as still twenty dollars poorer).

So what are the chances your big life in-rance policy will mature before a meteor ars off most of the earth's surface? Take from me, you'd have better odds putting wn money on a rerun.

olklorist Roger L. Welsch lives on a tree rm in Dannebrog, Nebraska.

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Crusaders of the Lost Park

by Joseph L. Sax

The story is true, but it reads more like a scenario for an Indiana Jones movie than like an account of a scientific expedition. The tale goes something like this: Mark and Delia Owens are ousted from Botswana because they had publicized the toll commercial ranching was taking on the desert's wildlife, so the Owenses seek a new place in which to continue their research on the social life of lions. They decide on North Luangwa National Park in Zambia, a roadless, uninhabited area the size of Delaware and home to zebras, hippos, buffaloes, crocodiles, lions, and—ominously, as it turns out—thousands of elephants.

The Owenses settle in to begin their work. Their basic equipment is a Toyota Land Cruiser and a Cessna 180K, which Mark uses to track the wildlife they have collared. But the park is not the untrammeled wilderness it appears to be. It is a vast elephant killing field. Day after day the same scene is repeated. A cloud of vultures appears, and smoke is seen rising from a fire. The remains of slaughtered elephants litter the ground. Often the elephant hunters can be seen from the air, sitting near a fire roasting huge pieces of meat they will sell. Ivory is waiting nearby to be carted away. Everything is blatantly illegal, but the poachers operate openly in the remote savanna.

THE EYE OF THE ELEPHANT: AN EPIC ADVENTURE IN THE AFRICAN WILDERNESS, by Delia and Mark Owens. *Houghton Mifflin Co., $22.95; 305 pp., illus.*

The Owenses see an opportunity to use their presence and equipment to bring an end to the wanton killing. There are game guard stations on the park boundaries, and Mark and Delia anticipate spotting poachers from the air, notifying the park authorities by plane and radio, and directing them to the scene. But it is not quite so simple, as the following passage (a typical one) reveals. Delia relates how, when Mark discovers elephants being slaughtered, they rush to the nearest station:

> A few scouts stand around, leaning against the truck. Tapa...yawns. Nelson Mumba...walks away....
>
> "We have no ammunition," Zulu tells us.
>
> "What happened to it?" Mark asks. Mosi Salma, the warden in Mpika, swore to us that each man had been given his monthly allotment of five rounds. The scouts look at each other, speaking in Chibemba. As before, all agree that they have not received their allotment....
>
> Mark senses a faint willingness in Phiri [one of the guards]. "Mr. Phiri, I will pay every man who comes with us two hundred kwachas for each poacher he catches."
>
> "But we have no food for patrol," says Phiri.
>
> "We will give you food," I interject.
>
> Eventually six of them agree to come, but they will need two hours to get packed.
>
> We urge them to hurry, so that we can catch the poachers before daybreak, but Phiri tells us, "We cannot patrol at night...."

The reader catches on pretty quickly, but the Owenses apparently take a good deal longer. For many months they try to mobilize the park guardians into action. They provide the game guards with food and ammunition, transportation, cash bounties, clothing, and even an educational program. Nothing works. Delia laments, "with each discovery we plead with the game guards to go on patrol, but there is always some reason why they cannot. They have not mounted a single patrol on their own since we arrived last year." Of course it is not just that the game guards won't catch poachers. They are poachers themselves, and are employed by other poachers as well. So is the chief warden, and the district governor, and others, all the way up to the minister. Instead of receiving help from the government, Mark was charged with operating an airstrip without a license, and with unauthorized use of radios.

The Owenses were discovering that—to paraphrase an old-time Chicago alderman upon being confronted with evidence of flagrant corruption—"Zambia ain't ready for reform." Mark and Delia are o viously not easily discouraged. Del began an imaginative program, focuse largely on children, to teach conservatio even importing copies of the children magazine *Ranger Rick*. They als preached the benefits of tourism, pointin out that elephants could be worth mo alive than dead. And they instituted the own little AID program, trying to impla sustainable cottage industries to wean vi lagers off the poaching economy.

Meanwhile the poaching continue and Mark, frustrated by his inability to g the game guards to act, strapped on h pistol, got into his plane, and constitute himself a one-man army. The poache struck back at anyone who helped th Owenses. At one point, Mark reports:

> Gunshots shatter the darkness outside...bu lets punch through the walls, kicking o puffs of dust and dry clods of dirt.... [Th poachers] have poisoned...two of our oth men. Clearly, they are upping the ante. they can do it, so can I. But I will have to d it alone. I've had it with scouts.

What makes the book seem like a Ho lywood concoction are the events that fo low. Mark harasses the poachers by plan buzzing their camps, flying at treeto level, scattering them and making ther abandon their take. He single-handedl flies game guards to remote airstrips packs them off toward poachers' camps and drops supplies to them. The guard don't do much of anything once they ge there, but their presence is disruptive When that doesn't work, Mark attacks th poachers with firecrackers, droppin cherry bombs (no kidding!) from th plane. For a while it works. Until they fig ure out that the firecrackers are harmless poachers stay clear of the park.

On another occasion Mark hears tha the park warden is about to release a noto rious poacher who has finally been ar rested.

> "Oh no he's not!" Mark shouts over th mike. "Don't let anything happen! I'll be i Mpika in thirty minutes." Mark jumps int

plane and flies to Mpika.... No doubt a
be has changed hands, but this time it
n't work.... Mark roars up to Mpondo's
adside Bar and jams on the brakes, a
ud of dust swirling behind him. He
rches inside the ramshackle building and
ks around the dimly lit room.

ark sees that handcuffs are slapped on
malefactor and personally leads him
ay to be interrogated.

Needless to say, all this makes for fasci-
ting reading and even a happy ending.
lia and Mark survive to write the book.
lia reports that when they arrived in
86 the elephants of North Luangwa Na-
nal Park were being poached at the rate
a thousand each year. By the end of
91 that number had been reduced to
elve. Events outside Zambia con-
buted significantly to that outcome. In
89 the United States, the European
mmunity, Canada, Switzerland, and the
ited Arab Emirates imposed a ban on
importation of ivory. The U. N. Con-
ntion for International Trade in Endan-
red Species voted to list the African ele-
ant as an endangered species. The sale of all elephant parts was prohibited for two years beginning in 1990. A number of African nations (including Zambia, on and off) agreed to support an international ban on the ivory trade. In 1991 a new government came into office in Zambia, replacing the previously corrupt regime. The new president, Frederick Chiluba, made a commitment to conserve Zambia's natural resources, including its wildlife.

For all the sometimes-comical heroics, *The Eye of the Elephant* is a serious book about a grave problem, and the Owenses—already well known for their 1984 work, *Cry of the Kalahari*—are courageous figures in the effort to protect the diminishing wildlife of Africa. The book makes clear their appreciation of the difficulty of making a sustainable, ecologically compatible economy a reality in places like central Africa. It also reveals how narrow the window of opportunity can be. Great effort notwithstanding, there may be nothing left to save by the time governments and the international community get organized to act. Zambia alone lost 80 percent of its elephants in one decade. With statistics like these, the frustration that led to Mark Owens's exploits is understandable.

The Eye of the Elephant is a provocative, disturbing, and eminently readable work. One cannot put the book down without reflecting on the bizarre global economy that produced the circumstances the Owenses describe. Somewhere far away, and despite the ghastly history of the ivory trade, people wanted ivory badly enough to bid the price up to nearly $150 per pound. An African elephant's tusks may weigh several hundred pounds. Yet the people of the Luangwa Valley received only $10 to kill an elephant, and even then, with the poaching economy at its height, they continued to live a simple, even marginal, existence. The benefits went to the big-time poachers and to corrupt officials who were running the country. Its wildlife is one of Zambia's most precious assets, yet its government was unable to mobilize itself to protect the natural heritage.

Two Americans literally dropped out of the sky and appointed themselves the guardians of the country's wildlife. Admirable and decent as they are, it is impossible to read the Owenses' description of their work in Zambia—exchanging trinkets and sewing machines for promises not to poach—without thinking of the missionaries of another time and how little they really understood the people to whom they preached. The Owenses' gospel is the gospel of tourism. Perhaps they are right. Perhaps they are prescribing good economics. But I wonder what the people of the Luangwa Valley really think. And I wonder if there is not something more to be said in favor of the existence of the largest living land mammal.



hen poaching was suppressed in Zambia's North Luangwa National Park, ephants again began to drink at the rivers by day.
rk Owens

Joseph L. Sax is James H. House and Hiram H. Hurd Professor of Environmental Regulation at the University of California at Berkeley's Boalt Hall School of Law. He is the author of Mountains Without Handrails: Reflections on the National Parks.

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New research in Peru, Chile, and Bolivia has documented the statecraft, religion, art, science, and culture of Tiwanaku, an excavated city-state high up in the southern Andes at 12,000 feet. American Museum archeologist Paul Goldstein will talk about the domination of Tiwanaku in ancient times, almost 1,000 years before the arrival of the Inca. The slide-illustrated lectures will be on two Mondays, March 1 and 8, at 7:00 P.M. in the Kaufmann Theater. A ticket for both talks is $25. Call (212) 769-5310 for information.

The Soviet Space Program

Russian cosmonaut Georgi M. Grechko, of the Laboratory for Atmospheric Research in Moscow, will recount his career in the once top-secret Soviet space program. The slide-illustrated talk will be held in the Planetarium's Sky Theater on Wednesday, March 3, at 7:30 P.M. Tickets are $8 ($6 for members).

Jumbo and his Relations

Jumbo's capture in 1861 in Africa, and his subsequent fame in England and in the United States, aroused widespread public curiosity about the hitherto unknown African elephant. Richard Van Gelder, former curator of the Museum's Department of Mammalogy, will talk about the African elephant's natural history on Saturday, March 13, at 2:00 P.M. in the Linder Theater. Call (212) 769-5310 for information.

Quincentennial Perspectives

The Museum's education department continues to present free programs on the Columbus Quincentenary, this month focusing on cultures and traditions of women after European contact.

On Sunday, March 7, the Sullivan Street Players explore issues of women coming of age in today's world. Highlighting the African pantheon of female divinities in Cuba, Haiti, and Brazil, Judith Samuel-Rock and Children of Dahomey will present a dance program entitled "Sisters" on Wednesday, March 10, at 7:30 P.M. in the Main Auditorium.

North and South American native cultures will be celebrated in the Museum halls of Ocean Life and Invertebrates on Sunday, March 14. Three New Mexican women's personal narratives—known as *mitote*, or "woman talk"—will be performed as a one-act drama on Sunday, March 28.

Programs will also take place each weekend in the Leonhardt People Center. Highlights include the traditional and contemporary music of Native Americans by Pure Fe and Soni; music and dance by Marilyn Worrell and Phyllis Bethel depicting a woman slave's passage; and Carmelita Tropicano's perspective on being a Latina. For a full schedule of events, call (212) 769-5315.

Echo of the Elephants

Cynthia Moss, senior associate with the African Wildlife Foundation, will speak about her latest work in Kenya's Amboseli National Park with the fourteen-member elephant family presided over by the matriarch Echo. In eighteen months of following Echo and her kin, Moss was able to observe closely the group's day-to-day behavior. The talk will be on Thursday, March 4, at 7:30 P.M. in the Main Auditorium. Tickets are $12 ($8 for members).

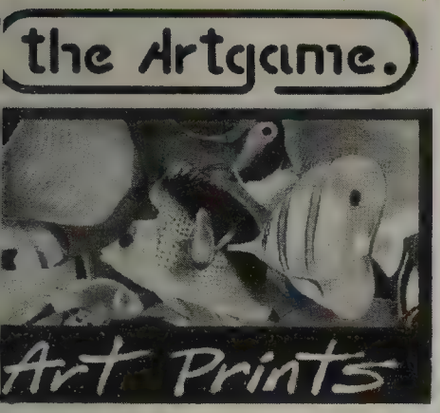
Making Silent Stones Speak

Using evidence from the savannas of East Africa, the plains of northern China, and the mountains of New Guinea, archeologist Nicholas Toth will discuss Stone Age tool use. The program, on Tuesday, March 9, at 7:00 P.M. in the Kaufmann Theater, is presented in conjunction with the opening of the Museum's Hall of Human Biology and Evolution. Tickets are $7 (members free).

From Nefertiti to Cleopatra

Priestesses played key roles alongside the Pharaohs in ancient Egypt. Robert Steven Bianchi, J. Clawson Mills Fellow at the Metropolitan Museum of Art, will talk about male–female relationships in ancient Egypt on Friday, March 19, at 7:00 P.M. in the Kaufmann Theater. Tickets are $10 ($6 for members).

These events take place at the American Museum of Natural History, located on Central Park West at 79th Street in New York City. The Leonhardt People Center and the Kaufmann and Linder theaters are in the Charles A. Dana Education Wing. The Museum has a pay-what-you-wish admission policy. Call (212) 769-5100 for Museum information.



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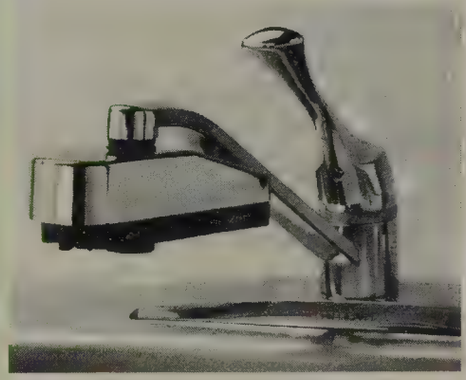
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THE CATALOG COLLECTION

The Teff Also Rises

Did the first naturally fermenting sourdough bread originate in Ethiopia?

by Raymond Sokolov

At the height of the cruel Mengistu regime in Ethiopia in 1985, I made a modest proposal in this magazine for exerting indirect pressure on that government to persuade it to treat its starving people with greater compassion.

My plan did not involve an expeditionary force of American soldiers such as recently went to Somalia to guard convoys of food. In fact, all I wanted was to divert some of the immense capacity of U. S. agriculture to the cultivation of Ethiopia's staple grain *Eragrostis abyssinica,* called teff in the classical language of Ethiopia, Amharic. The grain yields a tiny seed, about one hundred-fiftieth the size of a wheat grain, but that smallest of all cultivated grains is the basis of Ethiopian traditional cookery. Teff flour is the main ingredient of the spongy, pleasantly sour pancakelike bread known as injera, which literally underlies every Ethiopian meal. To set an Ethiopian table, one lays down a circular injera on top of which the other food is arrayed, directly, without the intermediary of any plate. Other injeras are served on the side and torn into pieces to be used as grabbers for the food on the "tablecloth" injera. Eventually, after the meal is finished, you eat the tablecloth, a delicious repository of the juices from the food that has been resting on it.

This method of eating is certainly worlds away from my own traditions, but it has had an immediate appeal for me and everyone I know who has tried it. And a large part of that appeal has been the opportunity to share in the refinement and wholeness of a very old and independent culture's foodways, right down to the table manners. But on its home ground in Ethiopia, this idyllic injera-centered cuisine was in dire trouble. During the catastrophic famine years under Mengistu, teff production had declined abruptly, and people were reportedly consuming the seed stock. Upon hearing this, my first assumption was that enlightened efforts at food relief could bring teff from the outside into Ethiopia. But teff did not really exist as a crop anywhere else. So it began to look as if traditional Ethiopian cuisine were doomed.

Of course, the Ethiopians could survive on other grains. They could even make perfectly traditional types of injera from sorghum, wheat, millet, rice, corn, and barley. And that is precisely what they were doing in the restaurants they established in exile in New York, Washington and other American cities. Nevertheless, it seemed tragic that teff should drop from view and, with it, one of the most defining features of an ancient way of life.

Fortunately, there was a way of saving teff, nonviolently, through a strategy of agronomic bootstrapping that might even save Ethiopia. It turned out that there was a modest seed stock for teff in the United States. My friend, the gardening writer Patti Hagan, located a supplier in Nevada selling teff seed to American gardeners who wanted to plant it as an ornamental grass (the company's delightful name and address—Garden Magic of Zephyr Cove, Nevada—matched teff's vernacular English name, "love grass," a direct translation of its Greek-derived genus).

My idea was for the Department of Agriculture to use the Nevada seeds to jump-start a commercial crop of teff. In short order, I argued, there would be a large enough supply of the grain to blackmail Mengistu into concessions on human rights. He could have our teff if he cleaned up his act.



A woman cleans teff in the Gondar region of Ethiopia.
Haroldo and Flavia de Faria Castro, FPG

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Ronald Reagan's Department of Agriculture paid no attention to me. Eventually, it didn't matter. Mengistu fell anyway. And at least one American grower went ahead and raised teff in serious quantity as a cash crop: Wayne Carlson of Caldwell, Idaho. You can find his teff for sale today in many health food stores.

Nutrition-minded Americans have turned to teff as a source of calcium, fiber, and protein. It is also an alternative grain for people allergic to the gluten in wheat. It has an appealing, sweet, molasseslike flavor. And it boils up into a gelatinous porridge.

So, no doubt unwittingly, Mr. Carlson has made my dream come true in a small way. His teff crop makes it possible for exiled Ethiopians to make injera in this country. Indeed, the largest Ethiopian community in America, in the Washington metropolitan area, has its own injera bakery as well as Ethiopian groceries that sell authentic teff injera in plastic packages.

This is an obvious boon for Ethiopian immigrants, who have also found ways of providing themselves with other crucial elements of their unique cuisine, from honey beer to false banana (*Ensete edule*). But for non-Ethiopian cooks, one of the unforeseen advantages of a ready supply of teff is that it offers an alternative route for the investigation of one of the mysteries of the kitchen, sourdough baking.

Injera is, among other things, a first cousin of the sourdough breads that have made specialty bakers in San Francisco, Paris, and lately New York famous and even revered. In the food press, much ink has been spilled over the essential mystery of sourdough—how to start it, how to feed it, how to keep it from getting too sour or from losing its fermentational oomph.

Part of the attraction of this subject is that no one really understands it. No one can say for sure what the sources of the souring are that make the dough—and the bread baked from it—so delicious. Aficionados do, however, agree on one thing: They don't use commercial yeast. For people like John Thorne, publisher of the quarterly food letter "Simple Cooking" and author of the gastronomic essay collection *Outlaw Cook* (Farrar, Straus and Giroux, 1992), and Jeffrey Steingarten, food columnist for *Vogue*, superior sourdough bread rises because of the symbiotic action of "wild" yeasts and naturally occurring lactobacilli.

This is an exceedingly complicated subject, to which I intend to return. But the basic idea is that the best bread is made by duplicating the conditions of the first yeast-risen bread.

Clearly, the first bakers of prehistory could not buy packaged yeast. They invented leavened bread by baking moistened flour that had begun fermenting spontaneously. The carbon dioxide produced as a byproduct of the normal activity of a yeast culture present in the air or in the wheat itself bubbled inside the moistened flour (dough) and made it double in bulk.

Wheat flour, which contains elastic gluten, rose especially well and, if treated properly in an oven, would retain the expanded cell structure produced by the gas even after the gas escaped during the baking process. *Voilà*!—leavened bread, hallmark of civilization at least as far back as the exodus of the Jews from Egypt. You will recall that they fled so quickly they didn't have time to wait for their bread to rise. So they ate flat bread, or matzo, remembered now at Passover meals as the bread of affliction.

So the Bible tells us two things about normal bread in ancient days: it was yeast-risen and the rising was time-consumi
It also seems likely that bakers back t
operated the way aficionados do tod
saving some of their active dough a
starter or "chef" for future dough batch
In this way they would have preserve
successful yeast/bacteria symbiosis t
was functional, produced a pleasant-ta
ing loaf, and resisted infiltration fr
other, noxious microorganisms.

The custom of saving a piece of dou
is still a symbolic part of the Jewish rit
of baking Sabbath bread. Originally,
olive-sized piece of moistened dough v
separated from the rest, before baking, a
given away, presumably as a sacrifice
something valuable, to the priests. Pic
Jewish women today burn the dough a
sign that it is not theirs any longer.

Jewish ritual also recognizes the o
nipresence of wild yeast. In an effort
give a precise definition to the idea of u
leavened bread, rabbinical law goes b
yond merely proscribing the addition
yeast to moistened flour. Bakers of prop
matzo must put the dough in the ov
within eighteen minutes of moistening t

Injera

¾ cup teff, ground fine (this may be done either in a flour mill or in a blender after moistening in 3½ cups water)
Salt
Sunflower or other vegetable oil

1. Mix ground teff with 3½ cups water and let stand in a bowl covered with a dish towel, at room temperature, until it bubbles and has turned sour. This may take as long as 3 days. The fermenting mixture should be the consistency of pancake batter (which is exactly what it is).
2. Stir in salt, a little at a time, until you can barely detect the taste.
3. Lightly oil an 8- or 9-inch skillet (or a larger one if you like). Heat over medium heat. Then proceed as you would with a normal pancake or crêpe. Pour in enough batter to cover the bottom of the skillet. If you use a teacup as a dipper, a little more than half its capacity of batter (about ¼ cup) will make a thin pancake covering the surface of an 8-inch skillet if you spread the batter around immediately after pouring it in, by turning and rotating the skillet in the air. This is the classic French method for very thin crêpes. Injera is not supposed to be paper thin so you should use a bit more batter than you would for crêpes but less than you would for a flapjack.
4. Cook briefly, until holes form in the injera and the edges lift from the pan. Remove and let cool.

Yield: 10 to 12 injeras

Yesuff Fitfit

Sunflower water mixed with injera

(Adapted from *Exotic Ethiopian Cooking*, by Daniel J. Mesfin, Ethiopian Cookbook Enterprise, 1987)

2 cups sunflower seeds
2 cups green (raw) jalapeño chilies, seeded and chopped
½ teaspoon onion, chopped
¼ teaspoon ginger, chopped
¼ teaspoon garlic, chopped
Salt
4 to 6 slices injera

1. Boil sunflower seeds in 6 cups of water for 15 minutes. Remove from heat, and drain off liquid.
2. Grind seeds in a blender to a paste.
3. Combine paste in a bowl, and add 4 cups water.
4. Mix and then strain liquid into a bowl. Discard paste.
5. Stir in jalapeños, onion, ginger, and salt to the strained liquid.
6. Break injera into small pieces and combine with liquid mixture. Refrigerate, and serve cold in a bowl.

Yield: 4 to 6 servings

r, to prevent leavening through the
t of the fermentation of naturally oc-
ing yeasts. In order to insure that no
roper or premature moistening takes
e, the orthodox begin supervising
zo flour when it is threshed. This spe-
y "watched" matzo, called *shmura*
zo, is always handmade. It is the polar
osite of the handmade loaves of the
-Talmudic sourdough aficionados.
When I originally heard about the Jew-
strictures on grain moistening at
sover, I dismissed them as, well, phari-
al, but that was before I had read John
rne on the subject of wild yeasts and
loom sourdough starters handed down
generations because of their estimable
lities. Thorne and the other aficionados
almost as obsessional about other as-
ts of breadbaking—rising baskets,
odburning ovens, bread cloches. But
notion of spontaneously fermenting
rdough is at the center of their preoccu-
ons (their quasi-scientific experimen-
ons recall Pasteur's revolutionary in-
igation of the misconception known in
day as spontaneous generation, which
him to unlock the mystery of the
mistry of fermentation in an experi-
nt that inaugurated the science of bacte-
ogy).
Thorne and company, all eloquent pros-
izers for wild yeast sourdoughs, seem
ave overlooked a large group of poten-
co-conspirators among injera bakers in
iopia and the world over. Perhaps this
ecause most published recipes for in-
obscure its historic identity as a true
f-fermenting sourdough. Modern
ipes written in this country usually
cify the addition of yeast or the use of
-rising flour (which contains commer-
yeast). But even these adaptations to
in exile in America call for a classic
rdough waiting period of two to three
s while the dough for teff injera fer-
nts and sours.
I am in no position to make sophisti-
ed aesthetic distinctions between natu-
y fermented teff batters and those made
h commercial American yeasts, but it
es seem obvious that the no-yeast recipe
lected by Steve Raichlen and published
the *Washington Post,* which I have
apted here, must reflect traditional prac-
e in the ancient kingdom of the Queen
Sheba before her descendants learned
w tricks in our midst.

*ymond Sokolov is a writer whose spe-
l interests are the history and prepara-
n of food.*

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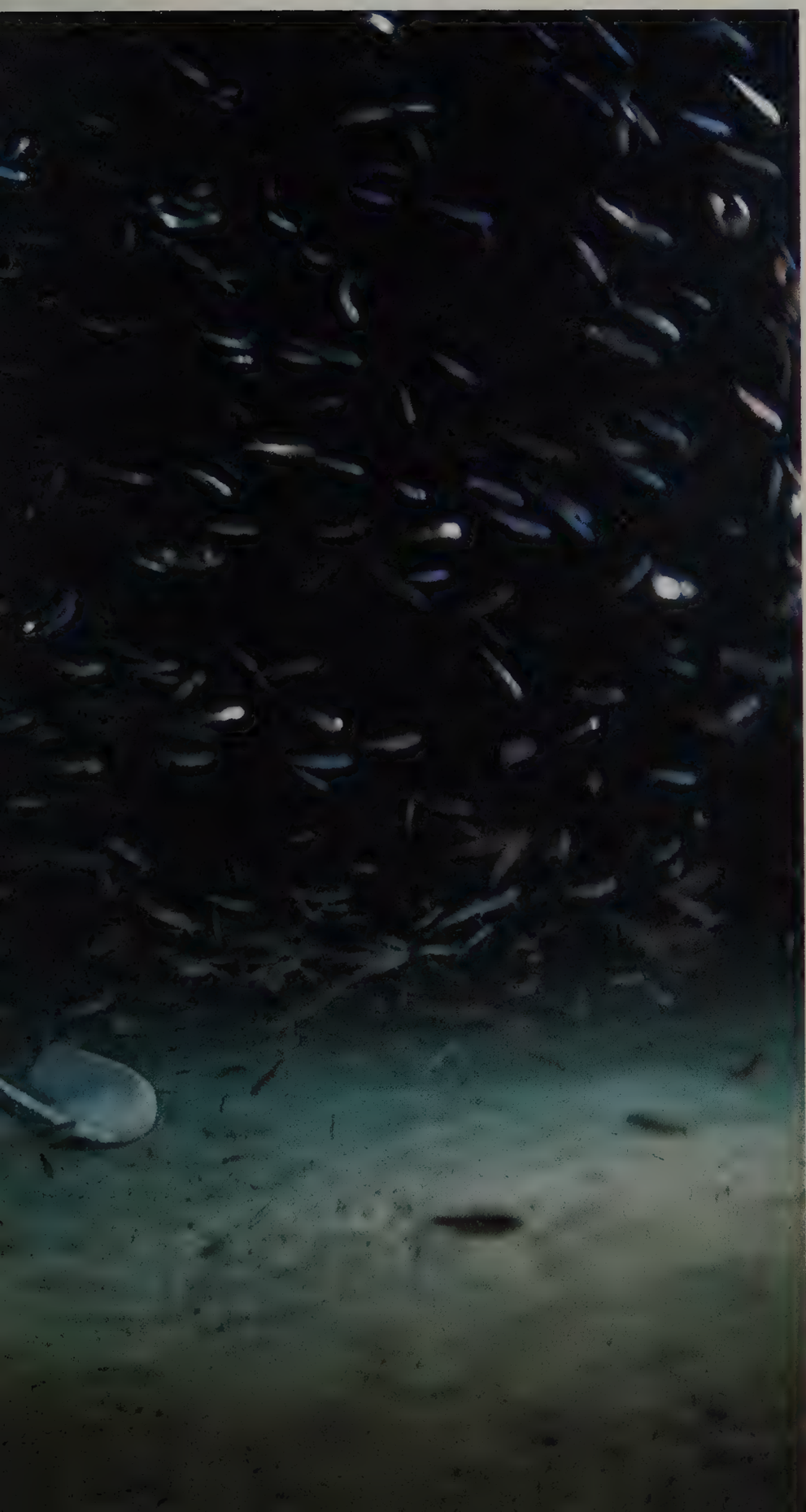


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Look Maw, No Teeth!

Maneuvering through a school of fish near Little Cayman Island, a manta ray with its mouth agape scoops up a nighttime snack. According to one ichthyologist, the small fish may be sufficiently panicked by the approaching ray to dart into its cavernous mouth seeking shelter. Just in case this doesn't happen, the manta ray uses the "cephalic" fins on each side of its head to funnel prey into its maw. When the animal is not feeding, these fins, which are distinctive to manta rays, are kept coiled in two hornlike corkscrews in front of its eyes, giving rise to the manta ray's other common name, the devil fish.

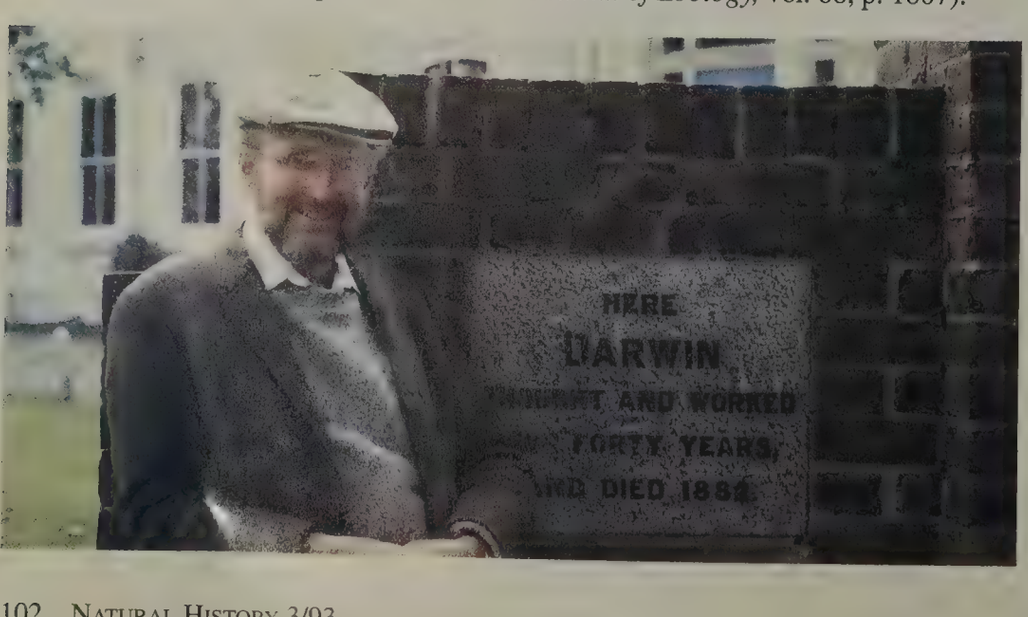
This manta ray measures about eight feet from wing tip to wing tip, but other individuals of the species *Manta birostris* often exceed twenty feet in width. To trap enough food as they move through the water, manta rays have evolved gills that double as strainers, the same equipment employed by their distant relatives, the enormous whale shark and basking shark. The gill rakers, which are visible on the bottom of the manta ray's mouth, collect small organisms, such as plankton, fish, or crustaceans, from the water just before it flows through openings on the animal's underside. This adaptation is so effective that the manta ray has all but lost the need for its tiny vestigial teeth.—*R. A.*

Photograph by Franklin J. Viola

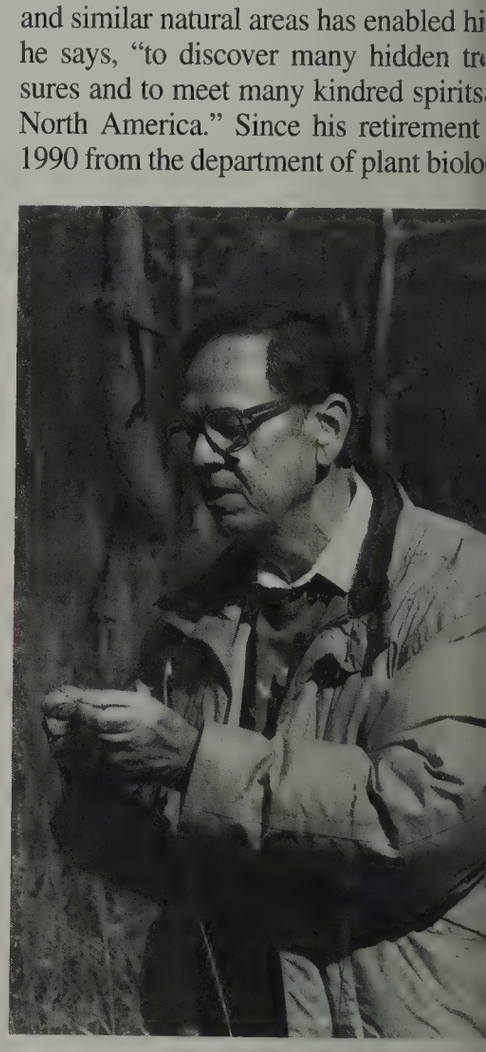


Since 1982, **Karen B. Strier** (page 34) has been investigating the life and times of muriquis, the largest New World monkeys. Her observations of the species' behavior and biology will, she hopes, help in the effort to conserve both the animals and their dwindling Atlantic forest habitat in Brazil. An associate professor of anthropology at the University of Wisconsin in Madison, Strier considers herself lucky to do field research and teach about the value of nature. She has written *Faces in the Forest: The Endangered Muriqui Monkeys of Brazil* (New York and Oxford: Oxford University Press, 1992), and for further reading she recommends *Ecology and Behavior of Neotropical Primates,* edited by R. A. Mittermeier et al. (Washington, D.C.: World Wildlife Fund, 1988).

William A. Shear's (page 46) interest in soil animals stems from his undergraduate days when he learned the Berlese technique, a way of sieving a community of hundreds of minute creatures from a small amount of soil and leaf litter. "Getting a Berlese sample," says Shear, "is like getting a Christmas present." He went on to earn a doctorate in evolutionary biology from Harvard and, over time, he has carried over his enthusiasm for living arthropods into paleontological studies of some of the earliest terrestrial animals. Shear and colleagues have identified mites, spiders, centipedes, and pseudoscorpions—and some creatures with no modern analogs—from fossil deposits in New York, Scotland, and Wales. The abundance and diversity of these fossil animals and their probable ways of interacting with one another suggest that life on land was full blown even 400 million years ago. A professor of biology at Hampden-Sydney College in Virginia, Shear continues to study modern and fossil arthropods and plans to research the biogeography of living soil animals in the Pacific region. For more information, he refers readers to Colin Little's *The Terrestrial Invasion* (Cambridge: Cambridge University Press, 1990) and "The ecology of Paleozoic terrestrial arthropods: The fossil evidence," by Shear and J. Kukalova-Peck (*Canadian Journal of Zoology,* vol. 68, p. 1807).

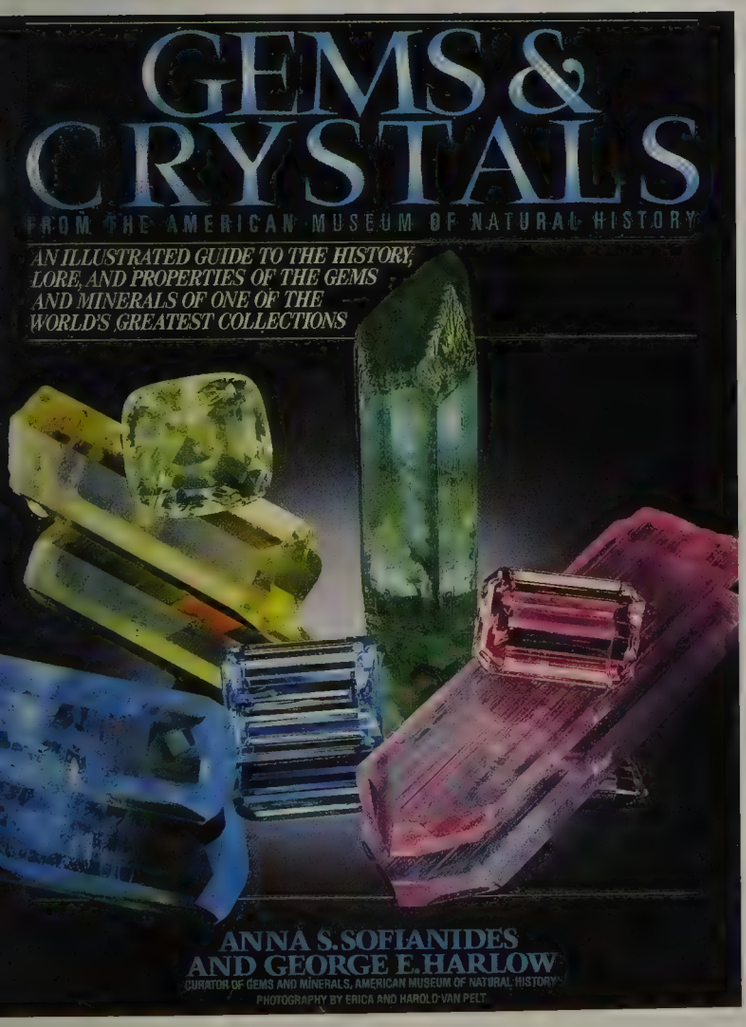


The one-hundredth column in **Rob Mohlenbrock**'s "This Land" series pears this month (page 30). The assi ment to cover the U. S. National Fore and similar natural areas has enabled hi he says, "to discover many hidden tr sures and to meet many kindred spirits North America." Since his retirement 1990 from the department of plant biolo



at Southern Illinois University, Mohler brock and his wife, Beverly, have travele extensively and have formed Biotic Cor sultants, a biological consulting firm Mohlenbrock teaches wetland plant iden tification workshops all over the country and has just completed a *Field Guide t Western Wetland Plants,* his fortieth boo and the third in a series being prepared fo the Soil Conservation Service. Mohlen brock is also finishing up the fourteent volume of his *Illustrated Flora of Illinoi* and is at work on the third edition of hi *Guide to the Vascular Flora of Illinois.* H serves as chairman of the North America Plant Specialists Group of the Interna tional Union for the Conservation of Na ture and is preparing the Red Data Book for endangered and threatened North American plants.

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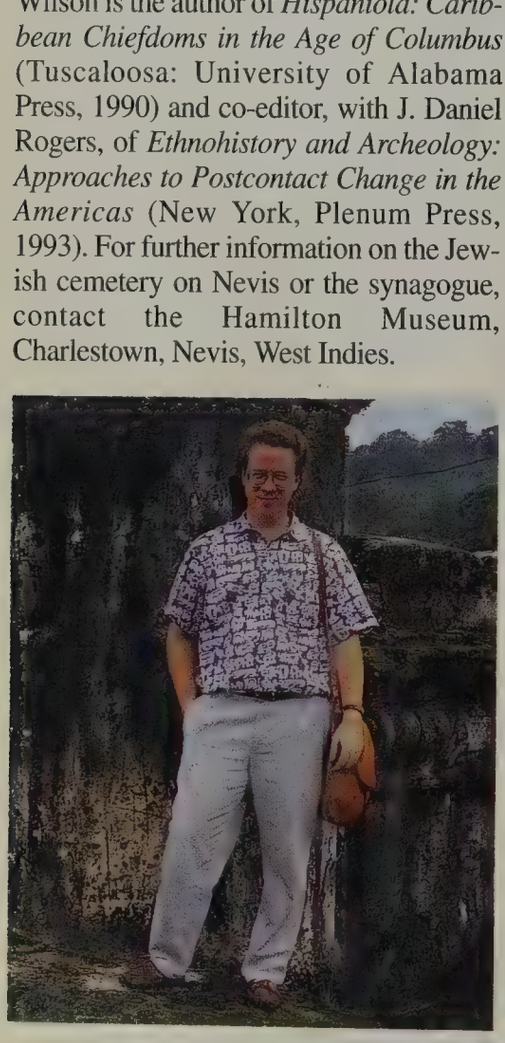
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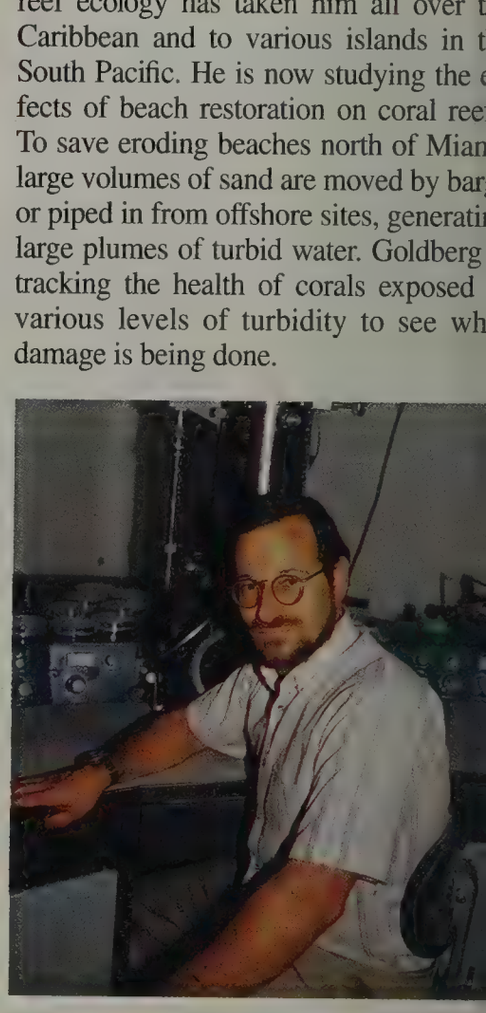
Author of the "Worlds in Contact" column, *Natural History* contributing editor **Samuel M. Wilson** (page 54) has been examining Caribbean prehistory and contact-period history for the past ten years. He delights especially in rediscovering the stories of past individuals, the immediacy of which is sometimes obscured in academic writings. He remembers the thrill of excavating an ancient storage pit in Illinois, leaning against a clay wall and finding his fingers resting in a handprint left by the person who had dug the pit 2,000 years earlier. An assistant professor of anthropology at the University of Texas, Austin, Wilson is the author of *Hispaniola: Caribbean Chiefdoms in the Age of Columbus* (Tuscaloosa: University of Alabama Press, 1990) and co-editor, with J. Daniel Rogers, of *Ethnohistory and Archeology: Approaches to Postcontact Change in the Americas* (New York, Plenum Press, 1993). For further information on the Jewish cemetery on Nevis or the synagogue, contact the Hamilton Museum, Charlestown, Nevis, West Indies.





A native New Zealander, **Ken R. Grange** (page 60) has been diving in the fiords of South Island for more than ten years. He first learned of the fiords' unique marine communities in 1979 from colleagues who had chanced to explore the dark waters after they were forced to sail their research vessel into a fiord to seek shelter from a storm. Currently, Grange is a marine ecologist at the New Zealand Oceanographic Institute in Auckland and president of the New Zealand Marine Sciences Society. In addition to his studies of the biology of black corals and other animals in the fiords, Grange conducts surveys of the marine ecosystems along the New Zealand coast, identifying those areas where protection and conservation are needed. Published accounts of the fiords' marine life are largely restricted to scientific papers, but for an overview of the Fiordland area, Grange recommends the park's own publication, *Mountains of Water: the Story of Fiordland National Park* (New Zealand Department of Lands and Survey, 1986).

Walter M. Goldberg is pictured h sitting in front of a scanning electron croscope, which he uses to probe the in structure of corals, the focus of his search. Goldberg teamed up with K Grange to study the biology of bla corals of New Zealand's fiords, after th met at a scientific conference in 198 Goldberg, originally from Massachuse worked his way down the eastern seabo while in college, ending up at the Univ sity of Miami, where he earned a Ph.D. marine biology in 1973. Currently, Go berg is chairman of the department of bi logical sciences at Florida Internatio University in Miami. His research of co reef ecology has taken him all over t Caribbean and to various islands in t South Pacific. He is now studying the e fects of beach restoration on coral ree To save eroding beaches north of Mian large volumes of sand are moved by bar or piped in from offshore sites, generati large plumes of turbid water. Goldberg tracking the health of corals exposed various levels of turbidity to see wh damage is being done.



Franklin Jay Viola (page 100) holds his underwater camera in a photograph taken by his wife, Kathy. During a night dive near Little Cayman Island in the Caribbean, Viola photographed the manta ray in this month's "Natural Moment." The ray was performing barrel rolls while swimming through a school of small fish that had been attracted by bright lights shining down from the dive boat. A native of Houston, Texas, Viola received a degree in marine science and another in marine transportation at the Texas Maritime Academy at Texas A & M University at



Galveston. He served as an officer in th U. S. Merchant Marine for six years, sav ing enough money to pursue his passio for underwater photography. During hi spare time in the merchant marine, Viol visited many of the world's prime divin spots. He and Kathy, who now live nea Atlanta, Georgia, often return to many o those locations, where they organize sem inars on marine biology and underwate photography. To photograph the mant ray, Viola used a Nikon F3 with a super wide, 16mm fisheye lens and double Ike lite 150 strobes.

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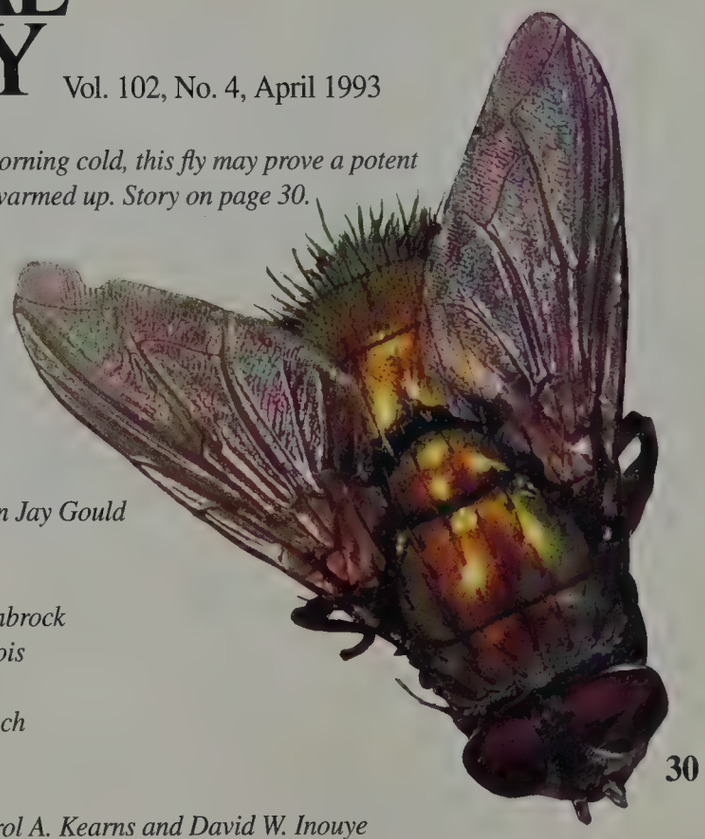
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NATURAL HISTORY

Vol. 102, No. 4, April 1993



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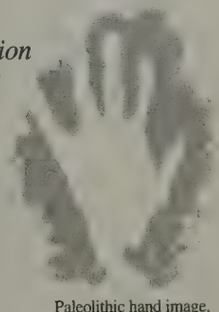
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LETTERS

UNSUNG SPECIES SAVIORS

Edwin Philip Pister wonderfully describes carrying all the world's Owens pupfish in two buckets ("Species in a Bucket," January 1992). It's a moving story that makes this reader eager to learn the names of the other people who saved the species: the "researchers" who, in 1964, found the remnant population in Fish Slough, and especially the alert assistant who, five years later, came into Pister's office and announced, "Phil, if we don't get out to Fish Slough immediately, we're going to lose the species."

ANNIE DILLARD
Middletown, Connecticut

EDWIN PHILIP PISTER REPLIES:

Key players on that eventful afternoon of August 18, 1969, were the "alert assistant," UCLA graduate student Robert E. Brown, Jr., of Castle Rock, Washington, and John M. Deinstadt, then my assistant and now supervisor of the California Department of Fish and Game's wild trout program.

The researchers who found the remnant population were the late Carl L. Hubbs, of Scripps Institution, and Robert Rush Miller, his son-in-law and former graduate student. Miller had described the Owens pupfish as part of his dissertation in 1948 and feared it was approaching extinction. A combination of science and sentiment brought them to the Owens Valley in July 1964 to check on the possibility of relocating the pupfish population. Now professor emeritus at the University of Michigan at Ann Arbor, Miller remains one of the nation's preeminent ichthyologists.

When Miller invited me to tag along on their reconnaissance trip, I assured my supervisor in Los Angeles that I would give them no more than a day of my time, because "it is not uncommon for eminent individuals to expect one to 'drop everything' during a visit of this type" (my exact words). That trip was my road to Damascus. Not only did I "drop everything," but I have never since bothered to pick it back up. If I had failed to accompany them, the Owens pupfish would probably now extinct.

THE RIGHT CATFISH

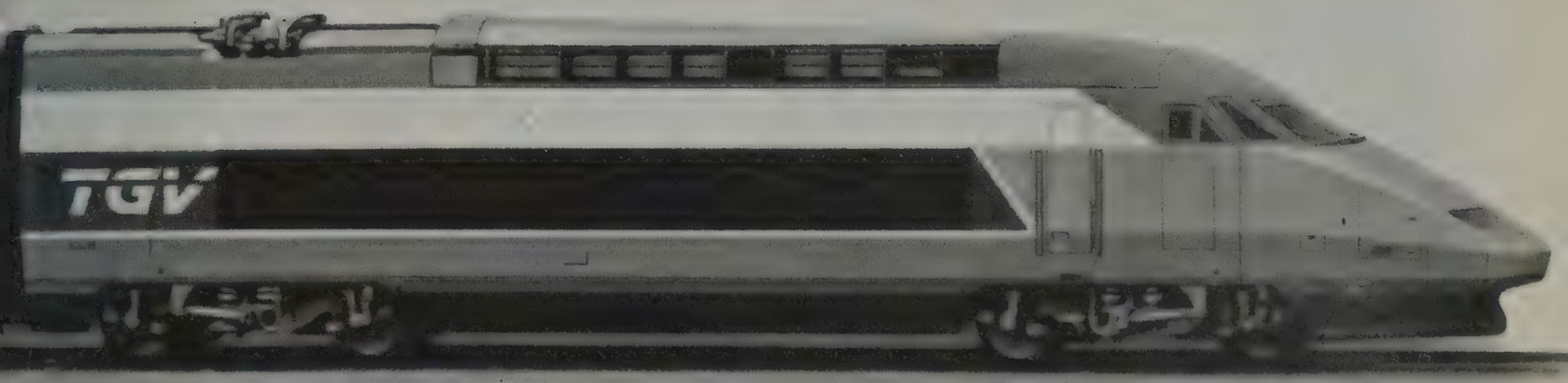
In "Family Planning, Amazon Styl (December 1992) there is a photograph a Shipibo man skinning a catfish. The ca tion identifies the fish as an armored ca fish. It is, however, a member of one of t naked-skin catfish families, and becau of the coloration of the dorsal and caud fins (and including perhaps the adipo fin), I can with fair certainty identify it



Phractocephalus hemioliopterus. Thi species indeed grows to a length of 1. meters and a weight of about 80 kilos, bu most specimens caught in recent years ar well below that maximum.

WARREN E. BURGES
Neptune, New Jerse

ERRATUM: The editorial department re grets that it was in error by a factor of te in converting the weight of kinglets an chickadees from grams to ounces i "Kinglets' Realm of Cold" (February 1993). As noted by several astute readers kinglets weigh, not 2 ounces, but about .2 ounces; chickadees about .4 ounces.



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Cuisine of Survival

In spite of food shortages and political turmoil, creative Iraqi cooks have been making delicious meals for centuries

by Elizabeth Warnock Fernea

Maqluba means "upside down" in Arabic. During and since the Persian Gulf war, Iraq has become figuratively *maqluba*: its homes and factories destroyed by bombing, its people torn by factional strife, its food and water supplies disrupted. The world watches as the Iraqis suffer from the expansionist foreign policy of their president, Saddam Hussein, and from the aggressive Allied responses that have followed.

But *maqluba* is also the name of a particularly mouthwatering Iraqi dish, one served to family and guests on special occasions. The week in 1958 that my husband, Bob, and I left Iraq after two years of social anthropological research in a southern village, Sitt Samira, the mother of a close Baghdadi friend, made *maqluba* for us. Turned upside down (or right side up) on the festal table, the delicately browned *maqluba* looked like an exotic cake without icing. But when Sitt Samira ceremoniously cut into it, releasing a mist of appetizing steam, we realized that this was no cake but rather something we had never encountered in this form before—meat, vegetables, and rice, combined with unknown, aromatic spices.

"You didn't find this in the village where you lived," Sitt Samira asserted, with the self-satisfied air of a recognized master chef. "After all," she added, "it's not so long since those people were Bedouin, right? And what did they eat? Dates and bread and camels' milk."

"Meat too, when they could," put in Bob mildly.

"*Boiled* meat!" Sitt Samira sniffed, reflecting the disdain of the urban, cosmopolitan Baghdadi (who has been attending to the requirements of *haute cuisine* for more than a thousand years) for the simple cooking techniques of the rural dweller and the nomad. But whether urban, rural, or nomadic, Iraqi cooking is distinguished by its antiquity.

The rituals surrounding the offering and accepting of food are fixed and time-honored. To neglect to serve something to eat or drink to guests, expected or unexpected, is a serious breach of polite behavior. To refuse food or drink, once offered, is just as serious. Before eating, one washes one's hands and offers thanks to God. In more traditional settings, conversing while eating is not considered appropriate; idle chatter would belittle the meal itself.

Originally part of Mesopotamia—roughly the area between the Zagros Mountains and the edge of the Arabian plateau—Iraq has been a nation only since 1919, when the British and French carved up the Middle East at the Paris Peace Conference following World War I. The area, like the rest of the Middle East, had a long colonial past, and, with the exception of the British, each of its occupiers—Turks, Persians, and Arabs—left something of its own ways with food. The only British legacy seems to have been cornstarch pudding, but even this is a variation on an old Egyptian favorite, *muhalabiyah,* or milk pudding. The combination of ingredients in *maqluba*—lamb, eggplant, rice, onions, and tomato sauce—suggests a Turkish influence, from the time when the Ottoman Empire loosely ruled most of the Middle East and Eastern Europe (ca. 1500 to 1918).

But Bob and I never ate *maqluba* in the southern Iraqi village of Daghara, where we spent two years as guests of Sheik Mujid Atiyah Al-Shaalan almost thirty-five years ago. These villagers were Shii Muslims and had resisted domination b the Turks, who were Sunni Muslim gravitating instead toward predominant Shiite Iran. We did have the good fortun however, to eat *faisanjun,* that classic Persian cuisine found in recipe books a over the world. Selma, the sheik youngest wife—and by virtue of h beauty, youth, and strength the natur mistress of the sheik's household—pr pared the dish to celebrate the end of tw weeks of rain.

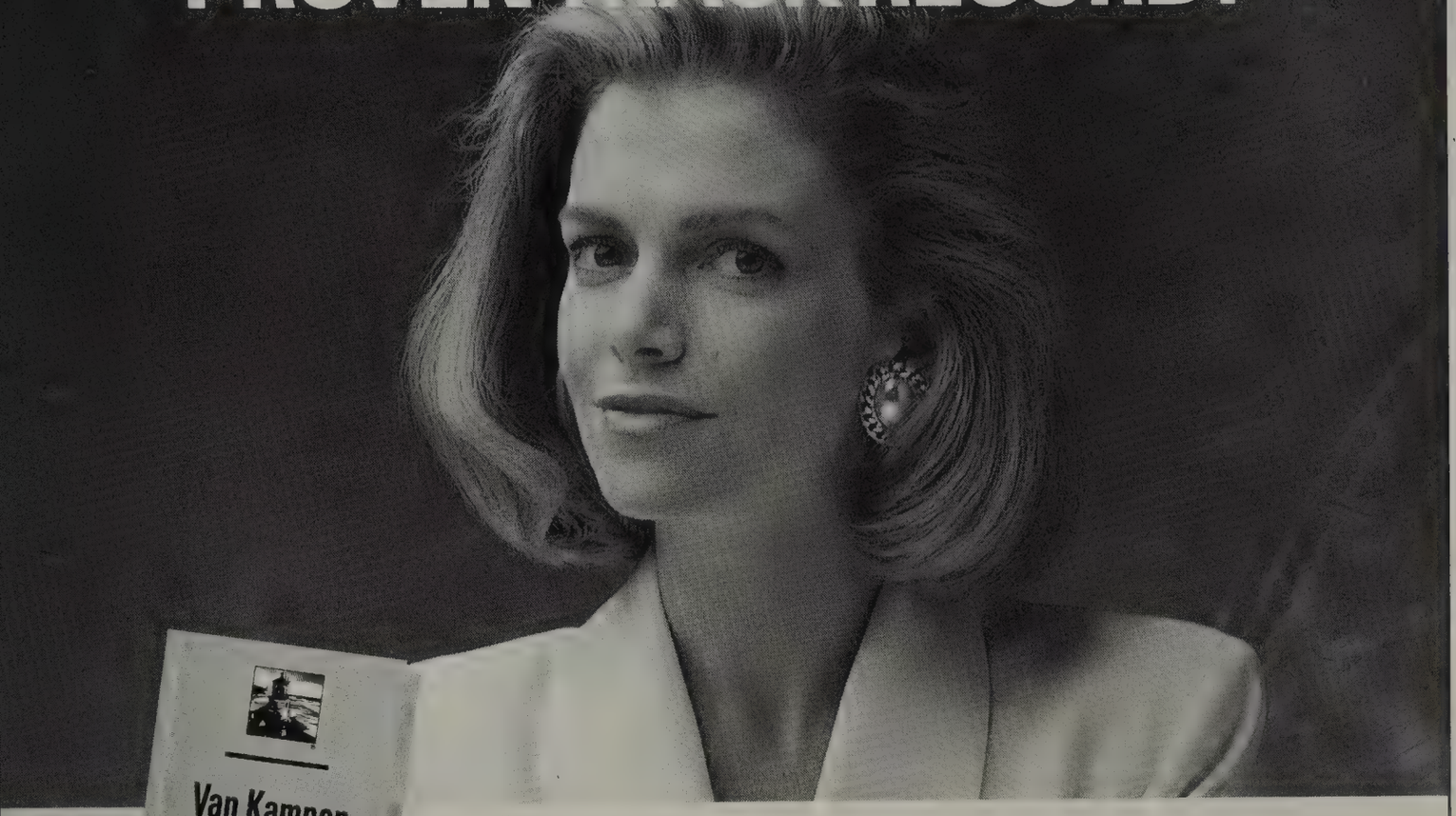
We had no idea what to expect when w dutifully separated along the muddy pat Bob to dine with the men in the *mudhiif,* guest house, and I to join the women in th sheik's private house. From the women enthusiasm, I gathered that the comin meal would be unique.

I was right. There was something spe cial about the dish brought in by Selma But when she removed the cover of th tray, my heart sank. The food was blac Dismay must have shown on my face fo Selma laughed. "Just taste it," she said. dish of sophisticated subtlety from Persi (now Iran), the *faisanjun* defied Sit Samira's assertion that nothing is cooke in villages but dates and boiled meat. Cor sisting of chicken, walnuts, onions, an pomegranate juice (which turned the foo black), *faisanjun* lacked the one thing ex pected in all Middle Eastern dishe today—the tomato—and thus dates fro before Columbus and the introduction o this New World fruit into the cookery o Europe, Asia, and the Middle East.

The women in Daghara cooked ever day. But since women did not usually ap pear in public, each morning a son or husband was dispatched to the market t

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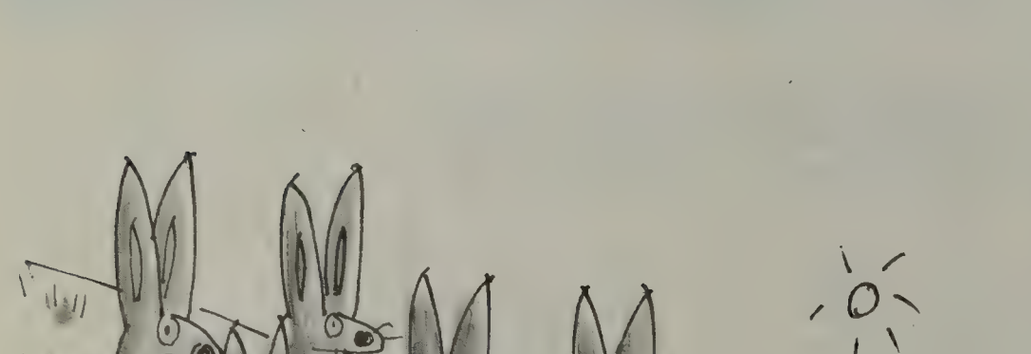
bring home a piece of meat, together with a selection of seasonal vegetables. The women supplemented these daily purchases with spices bought in bulk at the market and with ingredients from the private household stores "put up" at the time of harvest—rice, flour, garlic, clarified butter, or ghee, dried pomegranate, and tomato paste. On special occasions, a few raisins, pine nuts, or almonds from orchards in the mountains of northern Iraq might be folded into a rice dish or a stew.

The serving and eating of the food underscored hierarchal and familial relationships and Islamic injunctions to care for the less fortunate. The men ate first, older women next, children and wives after that. The leftovers went to servants, then to the poor, and finally—if any remained—to the animals.

What the family ate at home was private food. Public food was something else. In Daghara, food was a statement of political power. Two decades before we arrived, the British had suppressed the last uprising of the Diwaniyah tribes, and the area was controlled by the central government of Iraq under King Faisal II and President Nuri Said. But the tribes were still considered important politically, and the government, recognizing our host, Sheik Mujid, as a tribal leader, had made him a member of the Iraqi National Parliament.

The *mudhiif* was the sheik's office and reception room, where he saw clients and petitioners daily. In this impressive arched structure built entirely of reeds (reminiscent of ancient Sumerian buildings), the sheik served lunch every day to travelers, tribal members, and those in need—all men. When we lived there in 1958, rural Iraq boasted no public hotels, and the *mudhiif* served a crucial function as an inn. One could sleep in the *mudhiif* as well as eat there.

Each day the sheik's wives, sisters, and daughters cooked that free meal for twenty to sixty people. They worked hard, for the quality and quantity of the repast demonstrated the sheik's generosity and hospitality—and by implication his economic and political power. But the women did not publicly share the feast they had cooked; they ate by themselves. Selma supervised the loading of the trays with the food that had been prepared by all the women in the house. The boys and young men of the sheik's family bore the trays the hundred yards between the house and the *mudhiif* and served the meal.



THE REAL EASTER ISLAND

The menu was simple, as Sitt Sam would have expected: rice, bread, *ma* (stew), one or two extra dishes, and p haps a roast chicken for the sheik hims and his honored guests of the day. Th might include a government official, other tribal sheik, a religious authority, any person of high status who had bu ness to conduct. Bob, as resident m guest, was usually included in the gro Wives of the sheik's guests were w comed in the private house to eat with women after the men had finished.

Sitt Samira might have been surpris by some of the flourishes Selma manag even with the limitations of the local m ket. Plain rice, piled high on a tray, w embellished with crispy bits of butte crust. Bits of meat were crumbled w onions and used as garnish, together w home-grown parsley.

The bread was hot and fresh, bak each day in the *tanour,* the mud-brick ov that stood in every family courtyard. Fl circular loaves, set to rise in the ea morning, were clapped upright onto t insides of the *tanour* by the women each household, who were careful to w their arms to the elbows before braving t intense heat generated from the bank fire below. The trick was not in baking t bread (for the dough stuck to the sides ea ily enough) but in retrieving it at t proper moment—just before it peeled c and was lost in the blaze. Selma was fo of varying the kinds of bread—most *xubuz,* simple wheat bread, but often *x buz bi laham,* not-so-simple wheat bre baked with bits of meat, onions, and par ley. "A good way to use leftovers and praised for it," Selma said, half-jokingly

The best bread was made of wheat flou but because of overirrigation, the loc farmland was salting up and hardier barle flour was mainly being grown in th whitening, salty soil. "Rougher, but e ible," Selma explained to me. "But I a ways save some wheat flour to make bett bread for the feasts."

The feasts of *Iid al Fitr* (marking th end of Ramadan, the month of fasting) an *Iid al Adha* (commemorating Abraham sacrifice) called forth all of the women organizational and culinary talents. Du ing the three-day holiday, four or five hun dred tribesmen (and some women) woul come to pay their respects to the sheik an assure him of their loyalty. They tethere scores of horses near the *mudhiif,* partoo of the great communal repast, and gath ered afterward for sessions of poetry an chanting.



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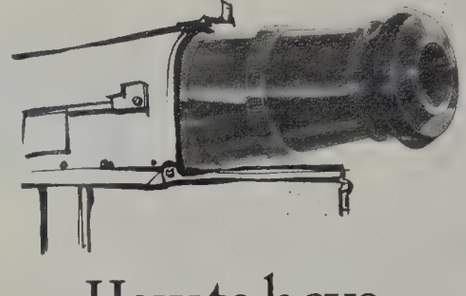
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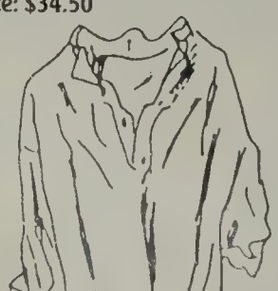
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For these great occasions, sheep and sometimes a cow were slaughtered. The animals were often stuffed with mixtures of rice, spices, onions, and raisins and roasted whole; they were then cut into edible pieces and arranged on enormous trays piled high with rice. Delicacies like liver and sheep's eyes were proffered by the sheik to special guests, sometimes to Bob. Women were not given sheep's eyes, and I was grateful in this case for my lowly status. (Bob told me the eyes were just like lumps of fat and went down easily!)

Everyday meals that Selma served were less dramatic and usually involved *marag,* a stew with vegetables that some have termed the national dish of Iraq. *Marag,* eaten by people in the countryside and city, by poor people and rich people, was eminently expandable or contractible, depending on the season and the family budget. Basic ingredients were meat, onions, garlic, spices, vegetables, and usually tomato paste.

For the poor, a sliver of meat attached to a cracked bone or two provided flavor for a large broth of vegetables (spinach, eggplant, okra, zucchini, green beans, peas, potatoes, and whatever else was in season). A richer *marag* featured meat as the main ingredient, flavored by vegetables. Lentils, lima beans, and fava beans were used if no fresh vegetables were available. Variations on *marag* for those with limited budgets included lentils cooked with rice and tomato paste or rice cooked with *sharia,* a kind of angel hair pasta.

With *kubba,* Selma could increase or decrease the amounts of expensive ingredients in a dish. The base of *kubba* was a mix of meat and wheat, pounded to a paste in a heavy mortar. This paste was layered in a pan, with more meat between layers in good times or more onions and spices in bad times, and then baked. The festal *kubba* that Bob and I sampled included pine nuts and raisins between the layers. *Kubba* could also be fashioned into smaller units, easier for children to eat. The paste was formed into a casing that could be stuffed with a mix of nuts, raisins, spices, and meat (good times) or merely with onions and spices (bad times). If Selma had no meat or, alas, no wheat, she could still make *kubba* out of leftover rice pounded to a paste and then stuffed. The *kubba* morsels were deep-fried (like Scotch egg) and guaranteed to keep stomachs full for many hours.

The more time we spent in Daghara, the more we realized that the local cuisine was the result of a creative human process that had been going on for a very long time deed. We were in the heart of the Tigr Euphrates valley, the legendary site of Garden of Eden and also where sett agriculture (as well as writing) began fore 3000 B.C.

Iraqis had lived for thousands of ye in a relatively fixed and comparative limited agricultural environment of ser arid land and limited water. (Iraq was j beginning to prosper from oil riches wh we were there in 1958.) Beside these a cient culinary traditions, our own Ame can national dishes—hamburgers a steak, for example—seemed extravag and even wasteful, since they depend for their succulence and flavor on the pr ence of seemingly unlimited natural sources—water, land, trees, and fatten cattle. When I once tried to explain American hamburger to Selma, she smil patronizingly. "Half a pound of meat one person? Ridiculous. It's not good you."

"Look at *kufta* or *kebab,*" I said. "Tha a lot of meat for one person, and it's grill like hamburgers, too."

"Yes, but that's when we've got lots meat and don't want it to spoil. I can fe at least twenty-five people with half pound of meat," she said triumphant "with *dolma.*"

She was right. For *dolma,* or stuff grape leaves, one pound of meat and cups of rice—mixed with onions, ton toes, and spices—fills a couple of hundr grape leaves or a reasonable number tomatoes, onions, peppers, zucchini, eggplant (anything that can be stuffed).

Selma steamed her *dolma* in *hindi* jui obtained by soaking dried tamarind water. The village of Daghara was close the Euphrates, which ran through the Sh al-Arab to the sea and the city of Basra port of call for sailing ships long befo Sinbad the Sailor was born. *Tamarhin* reached the village from India, as c spices—cumin, cardamom, allspice, bla pepper, cloves, cayenne, coriander, n meg, and cinnamon—and the techniq for making curries and for preserving b ter by clarifying it until it hardened in ghee. Thus, remote villages, disdained Sitt Samira, had their culinary ties not on to other Arab countries, Turkey, and Per but also the Far East.

Patscha, consisting of the feet, hea bones, scraped stomach, and intestines sheep, was another dish that demonstrat forcefully to us the use of every possib bit of edible food. These leftovers throwaways in our society—were si

ered with onions and spices in a broth
t Selma served with hot flat bread.
Many Iraqi dishes we sampled in those
o years represented centuries-old efforts
ease pain and reduce the effects of dis-
se. *Shaneena* was a good example, a
nk Selma offered me on an intensely
t summer day when I was ill. It con-
ted of equal parts of yogurt and water,
us salt—a perfect bromide for the in-
sely hot Iraqi summer, which can bring
dehydration first and then often disease
en water supplies turn doubtful. People
lieved that the salt was good for dehy-
ation and that the yogurt culture could
mewhat alleviate the deleterious effect
ditch water.
Selma knew how to make caraway tea
the stomach and cinnamon tea for a
od taste. She also knew how to make
y *hamudh,* or lemon tea, which every-
e in the village seemed to drink in the
nter for colds and bronchitis. Lemon tea
as made from *numi basra,* the beloved
rd-shelled, dark brown dried lemon that
day is carried far from its origins—the
uthern city of Basra—to London and
urich, Chicago and San Francisco, by
aqis as gifts to other Iraqis in exile.
We do not know what has happened to
e Iraqi village where we lived almost
irty-five years ago. We have heard noth-
g since the war except indirectly,
rough friends of friends, that life is hard
d food and medical supplies scanty.
As the effects of the war begin to re-
de, however, Iraqis must be doing what
dinary people have always done when
e clash of swords is stilled. After bury-
g their dead, they have to try to keep
ing. People must eat. The women must
making *marag* and *patscha* out of
hat's left, hoping for better days, when
ooking delicacies like *maqluba* and
isanjun will once more be possible.
Based on what's left and how many
eople must be fed, Iraqi cuisine is one of
eative survival; its adaptability to a con-
nually changing and disaster-prone
orld is worthy of our admiration.

lizabeth Warnock Fernea, a professor of nglish and Middle Eastern Studies at the niversity of Texas, Austin, has lived in e Middle East off and on for many years ith her anthropologist husband, Robert ernea. They recently collaborated on he Arab World: Personal Encounters *Anchor Press /Doubleday). She is also e author of* Guests of the Sheik: An thnography of an Iraqi Village *(Anchor ress /Doubleday).*



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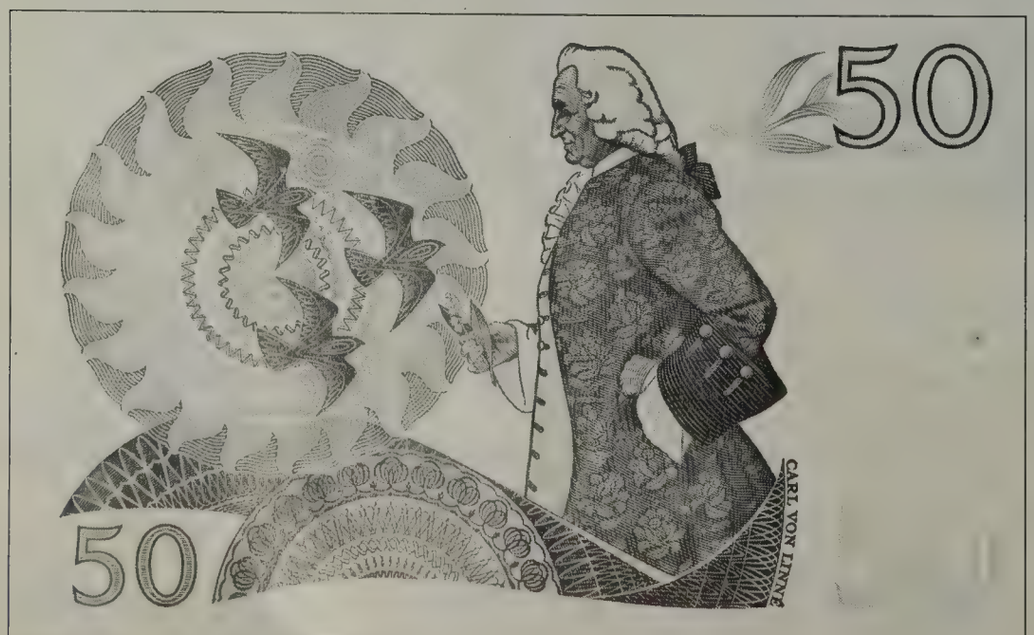
Darwin's revolution could proceed only after Linnaeus had revealed life's hidden order

by Stephen Jay Gould

I can't imagine two people in more intimate contact—just the tiniest sliver of a millimeter's separation—than the figures on the front and back of a bank note. We all know, of course, that the fall of any flower's petal reverberates throughout the universe to disturb the most distant galaxy; therefore, these closer juxtapositions cannot be without deep meaning.

During a recent visit to Sweden, I was delighted to encounter the common European practice of picturing scientists, rather than an uninterrupted parade of statesmen on bank notes—for Linnaeus graces two Swedish bills, just as Italy features Galileo, and the old British pound note had Newton backing up the Queen. (America similarly honors both Jefferson and Franklin but not, I think, primarily for paleontology and electricity.) I was, however, puzzled by a juxtaposition on the fifty kronor note: why do Linnaeus and King Gustav III stand in such minimal proximity (they even look directly at each other if you hold the bill up to the light and scan both figures at once)?





On one immediate level, the union poses no problem: both men were eminent and contemporary Swedes; Linnaeus lived from 1707 to 1778, and Gustav III, born in 1746, reigned from 1771 to 1792. Their personal ties were not close, but they certainly appreciated each other. The old scientist flourished in the atmosphere of the Swedish Enlightenment, so strongly promoted by this artistically inclined king (who collaborated on an opera when not overly engaged in affairs of state); while the young king basked in the prestige and honors won by Sweden's most famous naturalist and scholar.

In 1774, after Linnaeus had suffered a stroke and lost his legendary zeal for work, Gustav sent him a collection of plants from Surinam packed "in hogsheads of spirit." Linnaeus, according to legend, left his bed and went back to work, describing the 200 species sent by His Majesty. When Linnaeus died four years later, Gustav eulogized him before the Swedish legislature: "I have lost a man who did honor to his fatherland as a worthy citizen, being celebrated all over the world."

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Yet the principle of petals and galaxies tells us that a far deeper connection, something lovely and downright hermeneutical, must also link the two men—and I have found it!

We must begin by asking, Where do the majority of decently educated folks (like me and thee) encounter Gustav III, when our knowledge of things Scandinavian tends to be largely (and lamentably) blank between Thor and Ingrid Bergman? The answer, of course, is Giuseppe Verdi—for Gustav III is the subject of *Un ballo in maschera* (*A Masked Ball*). On March 16, 1792, King Gustav III was shot and mortally wounded while attending a midnight masquerade at the Stockholm Opera House. (His assailant, Jakob Johan Anckarström, representing an aristocratic conspiracy opposed to Gustav's reforms, was arrested, tried, convicted, flogged, and then beheaded after the offending hand that held the pistol had been hacked off.)

This wonderful opera is now usually performed in its proper Swedish time and setting. But not at its debut in 1859. An attempt had just been made on the life of Napoleon III, and the ever-watchful censors of Naples decreed that Verdi must change the locale and demote the king to some lesser station, lest any potential assassin be inspired by a night at the opera. Verdi was no stranger to such official intrusions. Seven years earlier, in Venice, a similar edict went forth from the censors for his opera about a jester named Triboulet in the court of Francis I of France. (We now know the opera for the renamed jester Rigoletto, while the French king was demoted to the Italian duke who sings "La donna è mobile.")

This time Verdi did an even better job of masking, for he switched the locale to, of all places, my present home of Boston. Gustav III was transmogrified, teleported, and demoted to the fictitious Riccardo, "Governor of Boston" at some unspecified colonial time. (Boston had no governor, although Massachusetts did; while the thought of a glittering masked ball at the opera house of this puritanical city continues to provoke endless amusement.) The conspirators were recast as a pair of miscreants named Samuele and Tommaso (Sam and Tom) traditionally played, we must note with sadness, either as Indians or blacks.

We therefore usually meet Gustav III in double masquerade: first, literally at the ball (where Anckarström needs half an act to find him); second, by Verdi in transferring him a hemisphere away and demoting him to governor. And now I know the deep connection to Linnaeus—for Nature was doubly masked when Linnaeus met h and although he succeeded only in remo ing the first disguise (we needed Darw for the second), uncovering an enti world must rank as a greater challen than discovering a king in a crowd of re elers.

Linnaeus is certainly acknowledg and honored among biologists. In t broadest realm, he developed the syste of binomial nomenclature still used (wi no substantial change since his formul tion) to designate and classify all orga isms. In the most parochial region, he ga us our own name: *Homo sapiens*. Yet I b lieve that we systematically underestima Linnaeus by measuring him against a fal view of how scientific knowledge grow We see him as a great organizer of know edge but, in an important sense, as a coc fier of error—for he believed that he h classified God's created order, not (as w now know) the products of a genealogic system built by evolutionary chang Some commentators have even viewed h role as retrogressive, as Linnaeus's cr ationist convictions canceled an older fo tradition of mutability, sometimes mi taken as a natural antecedent to evolutio if only the Linnaeans had not intervene (This older folk tradition spoke more occasional monstrosities and weird h brids between distantly related speci than of ordered systems changing by na ural laws. Fables about mutating beas and travelers' tales about fabulous cre tures in distant lands, do not qualify prototypical evolutionary theories.)

In this oversimplified view of scientif progress, we advance along a pathway accumulating knowledge, guided by timeless method of accurate observatio and relentless logic. The classic expre sion of this view can be found in the pre ace of a book that must be on everyone short list of contenders for the greate work of popular science ever writte T. H. Huxley's *The Crayfish* (his ma velous monograph on how to teach t most abstruse principles of science by d veloping the details of a single example, this case the anatomy and physiology of common animal).

Huxley begins by telling us that "sc ence is simply common sense at its bes that is, rigidly accurate in observatio and merciless to fallacy in logic." He the argues that the study of organisms has pr gressed through the same three stages fo lowed by all sciences in their develop ment: an initial phase of gatherin information without theoretical guidanc



"Tell your mother to get off my back!"

uxley calls this first step *Natural His-y*, defined as "accurate, but necessarily omplete and unmethodized knowl-ge"); a second stage of systematizing d organization, although still without ding theory (called *Natural Philoso-y*); and finally the third rung and syn-tic climax of *Physical Science*, "this al stage of knowledge, [where] the phe-mena of nature are regarded as one con-uous series of causes and effects."

In this system of three steps from unor-nized description to causal interpreta-n, Linnaeus occupies the middle rung. e are better off in Linnaeus's world be-use our previously unmethodized know-lge has been ordered into a coherent heme, but we are not yet there because have no decent theory for the causes of der. Huxley, in fact, argued that the third ge only began in his own century, fol-ving the death of Linnaeus and his ap-oach: "The conscious attempt to con-uct a complete science of Biology rdly dates further back than...the begin-ng of this century, while it has received strongest impulse, in our own day, from rwin."

I would agree with most modern histo-ns of science in branding this view as th misleading and unfair to our prede-ssors. I do not deny that science pro-esses in the crucial sense of achieving ore accurate and comprehensive expla-tions of empirical reality, but two as-cts of the older positivist view (so well emplified by Huxley) are quite wrong: e notion of a timeless scientific method sed on rigorously objective observation d logic and the idea that earlier systems ere either theory-free or theory-poor be-use explanation can only follow accu-e description.

Theory-free science makes about as uch sense as value-free politics. Both rms are oxymoronic. All thinking about e natural world must be informed by the-y, whether or not we articulate our pre-rred structure of explanation to our-lves. The old fabulists of Huxley's first ase had a theory—if only the folk idea at starlight or serious fright could influ-ce the form of a fetus in the womb. The xonomists of Huxley's second phase had theory—that God had created a timeless der for human ingenuity to find. These eories may have been wrong, but they ere as pervasive (and restrictive) in the ructuring of knowledge as any systems at followed. Linnaeus's *Homo sapiens* is thinking machine (or a thinking reed, if ou prefer the botanical metaphor); we cannot collect information without a theory to organize our searches and observations. Moreover, theory is always, and must be, colored by social and psychological biases of surrounding culture; we have no utterly objective observation or universally unambiguous logic.

With this perspective, we may return to the subject of unmasking and the comparison of Linnaeus with Gustav III—for if scientific progress depends more upon replacing theories than adding observations (and then waiting until they coalesce into a proper explanation), and if all theories are bolstered by cultural biases, then any process of replacement requires an unmasking of previous structures (protective clothing, whatever their virtues).

We must remove two disguises to reach Gustav III. We may also epitomize the history of our knowledge of organic order as a double unmasking. Linnaeus is the proper focus and symbol of the first great unmasking, Darwin of the second. This perspective challenges our antiquated and disrespectful view of Linnaeus as an old worthy who got it all wrong despite an admirable passion for order and allows us to see the great Swede as a scientist whose brilliant, coherent system fruitfully replaced a severely constraining theory.

Darwin tore away nature's second mask by establishing the explanatory basis for natural order in a theory of evolutionary transformation. But you cannot have a proper theory of order before you know the order that must be explained—and Linnaeus established this foundation with his method and practice of taxonomy. If Linnaeus had merely gathered and codified all the disorganized information long accumulating in Huxley's first stage, then we might say: "So what? Someone had to do it eventually; Linnaeus lived at the right time and was lucky enough to possess the right combination of zeal and tidiness." But Linnaeus didn't just codify; he unmasked. His system didn't just gather together; it replaced a different principle of organization that had hidden nature's order from our sight. We cannot conceive of Darwin without Linnaeus, of evolution without prior knowledge of taxonomic structure.

The first mask covered nature with our parochial penchant for viewing the universe as constructed either for us or in our terms. Artificial orderings by some system of human evaluation, or some principle of our mental or linguistic usages, can only mask nature's truly genealogical arrangement. Consider the monographs of the most famous systematizers at the inception of modern natural history—the great



"Good news! Nog has volunteered to be the first person on earth to eat a raw oyster!"

sixteenth-century scholars Ulysse Aldrovandi in Bologna and Konrad Gesner in Zurich. Aldrovandi used an eclectic system based on multiple, and sometimes contradictory, criteria organized only by some notion of importance to humans (or just noticeability by humans). He began his *History of Quadrupeds* with the horse, *quod praecipuam nobis utilitatem praebeat* (which exhibits particular use to us). His volume on birds mixes a range of criteria in its sequencing by human interest—from the noble (eagles and hawks considered first) to the wise (owls), the similar (bats, falsely placed), then moving to the big (ostriches), the awesome (gryphons), and on to parrots, crows, and finally, all the small things that go tweet.

Gesner makes even less appeal to any notion of natural order by simply proceeding through the Latin alphabet in his 1551 volume on mammals—from *De Alce* (on elks) to *De Vulpe* (on foxes). Gesner does follow the equally anthropocentric, but at least not quite so artificial, principle of the "chain of being" in sequencing his subsequent volumes—two on birds, three on cold-blooded terrestrial vertebrates. But volume 4 then amalgamates all water-dwelling creatures, with a primary emphasis on fishes (next step down the vertebrate ladder), although also including mermaids, medusas, and octopuses.

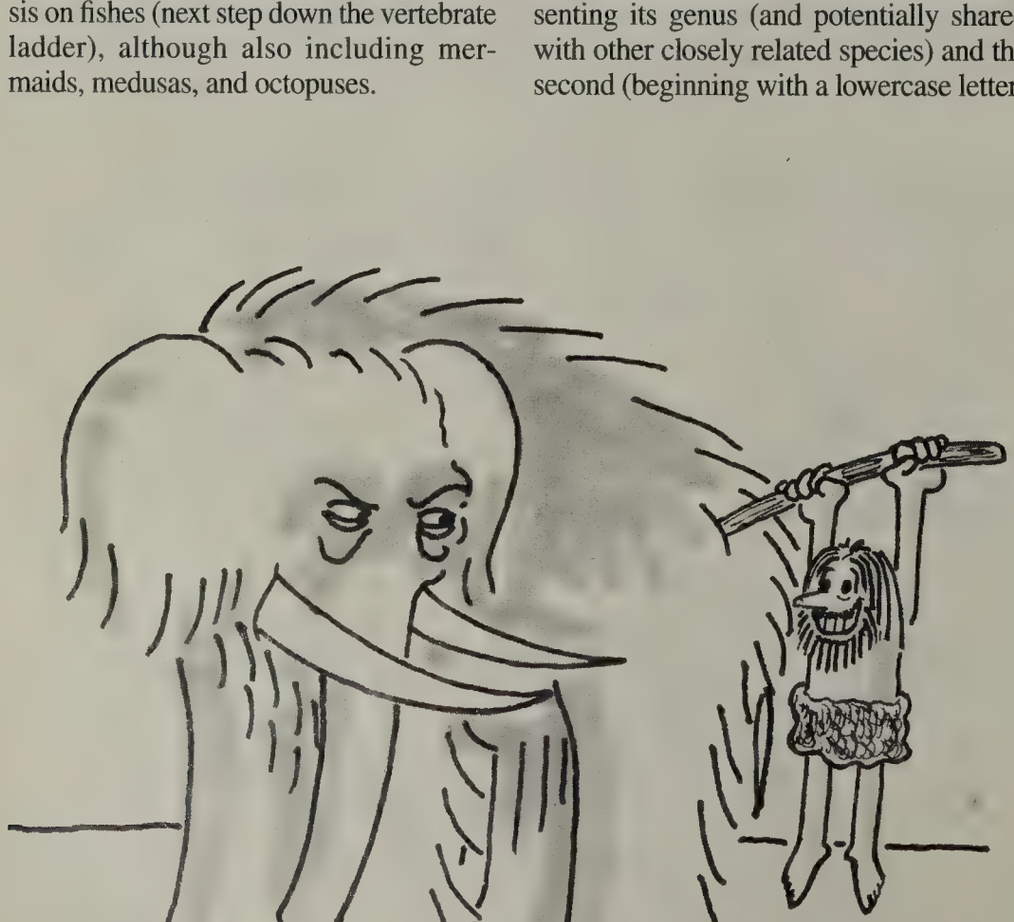
I do not say that Linnaeus was the first to question these anthropocentric systems or that his work makes a sudden break from this older tradition. He represents the culmination and codification of more than a century's work by natural historians throughout Europe, laboring on collections gathered throughout the world. But his legendary zeal and energy for work, his incredible memory and capacity for synthesis, led to a series of books—looking more like the products of an industry than the output of one man—that established both the practice and the structure of modern taxonomy.

Linnaeus produced his unmasking of nature at two levels—first, by designating species as basic units and establishing principles for their uniform definition and naming, and second, by arranging species into a wider taxonomic system based on a search for natural order rather than one of human preference or convenience. Linnaeus's binomial method has been used, ever since his *Systema naturae* (first edition 1735, definitive edition for animal taxonomy 1758), as the official basis for naming organisms. Linnaeus gave each species a two-word (binomial) name: the first (beginning with a capital letter) representing its genus (and potentially shared with other closely related species) and the second (beginning with a lowercase letter) called the trivial name, representing t unique and distinctive marker of a speci (Dogs and wolves can both be in the ger *Canis*, but each must have a separate tr ial name to designate the species—*Ca domesticus* and *Canis lupus*, in this case

Linnaeus did not invent this syste while seated in his armchair. He evolved from the usual convention of representi species by a string of Latin words epi mizing their distinctive characters. In t system, the first word (since it began t phrase) was capitalized, while the oth remained lowercase. Linnaeus first expe mented with regularizing the form a number of the word string (one of his e lier systems allowed a maximum of twel words per species).

He then decided that a summary of t summary, restricted to two words, mig work best as a device for tabulation a standardization. At first he regretted g ing up the key idea that a word stri should accurately describe the key fe tures of the species—for two words are r enough and may not even turn out to appropriate. (I am scarcely the first point out that Linnaeus may have err spectacularly in his most famous decisi to name us *Homo sapiens*.) But he later r alized that he had accomplished som thing enormously useful and clever wit out realizing why. The Linnaean speci name is not a description; it is a plac holder, a legal device to keep track and confer a distinctive name upon each na ural entity. Any comprehensive syste based on millions of unique items mu use such a mechanism, and Linnaeus nally understood that he had brought necessary and fundamental principle naming through the back door of a sear for modes of epitomized description (a d ferent problem solved in other ways).

But Linnaeus's definition of species not his mechanism for naming them codified the change that unmasked natu For Linnaeus's definition fractured t conceit of a human-centered system wi basic entities defined in terms of our nee and uses. Linnaeus proclaimed th species are the natural entities that G placed on earth at the Creation. They a his, not ours—and they exist as they ar independent of our whims. (We may ha trouble recognizing and defining them, b our difficulties do not alter God's action In a famous maxim (number 157) of t *Fundamenta botanica* (1736), Linnae proclaimed: *Species tot sunt diversae qu diversas formas ab initio creavit infinitu Ens* (there are as many species as the In



e Being created diverse forms in the be-
ning).

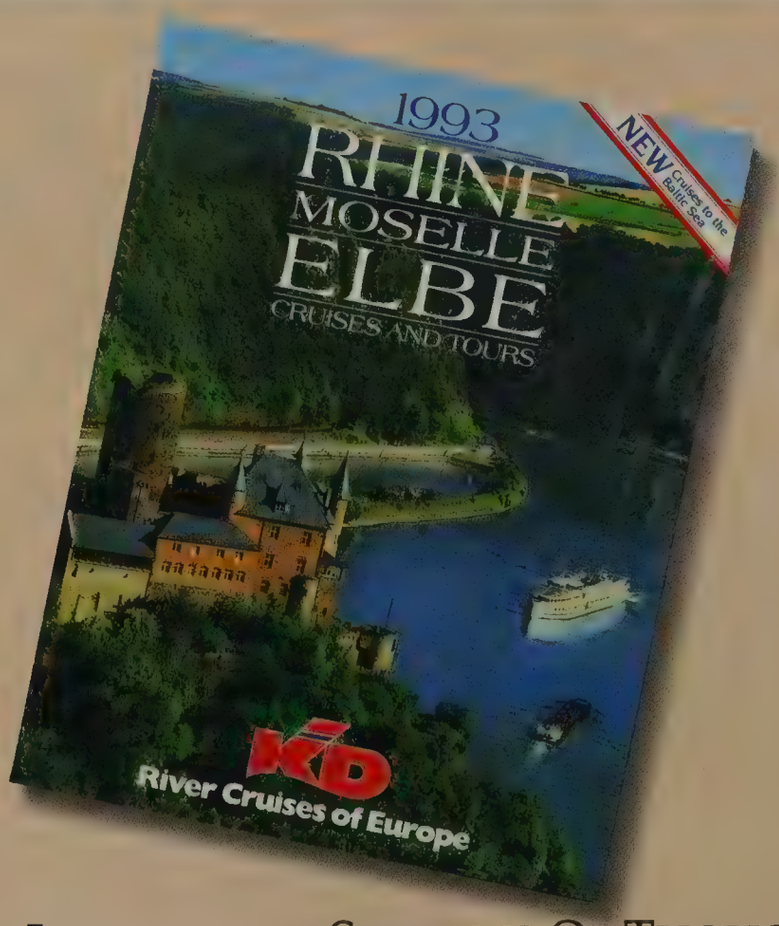
Since creationist-bashing is a noble and
cessary pursuit these days, readers may
nder why I am praising such an invoca-
n of God's power to create immutable
ities all at once—especially since Lin-
eus substituted this idea for earlier no-
ns of looser definition and mutability.
t, as I argued above, the history of sci-
ce progresses in such a manner—from
ory to theory along a complex surface
th a slant toward greater empirical ade-
acy, not along a straight and narrow
h, pushed by a gathering snowball of
tual accumulation. The conceptual
ange may be enormous, but Darwin's
stitution of natural selection in steps,
God all at once, did not require any
jor overhaul in practice. Species are
l whether created by God or con-
ucted by natural selection—and Dar-
n's conceptual shift, the second un-
asking, required little revision in
nnaean methods.

(Linnaeus later moved away from this
id insistence that God had created all
ecies at the beginning of time. In his
ly work, he repeatedly proclaimed: *nul-
e species novae* [no new species]. But
t as a recent president said something
nilar about taxes and lived to regret his
olishness, Linnaeus later argued that
w species could form by hybridization
tween pairs from the original creation.
e even toyed with the idea that God may
ve created only a common source for
ch genus, or even for each order, and
en allowed subsequent species to form
hybrids. Some commentators, falsely
lieving that we may honor only those
e deem right by today's standards, have
asped at these later views to recast Lin-
eus as at least a closet evolutionist. But
ch a strategy must be rejected on two
ounds. First, Linnaeus was decidedly
t an evolutionist. What can be more dif-
rent than a fully genealogical system,
sed upon constant change and common
cestry for all life, and a claim that God
ade fewer than all his forms at first and
en let the others slide into slots of a pre-
dained system by combination? Second,
nnaeus was a great scholar in his own
rms, a man who pulled the first mask
om nature as surely as Darwin snatched
e second. We don't need to clothe him at
rmani's in order to respect his accom-
ishments.)

At the second level of organizing spe-
es into a larger taxonomic system, Lin-
eus also fractured previous schemes of anthropocentric arrangement by insisting that relationships among species be ties of natural order, not human convenience. God had created according to a rational scheme; species are items that build God's framework. Taxonomists had been given the sublime job of discovering God's plan in the interrelationships among his species. (The ties are ideological in Linnaeus's system, not genealogical as in Darwin's—but chains of implication among ideas are no less firm than links of matter in physical continuity.) This key point was beautifully expressed by none other than Dag Hammarskjöld in an address on the 250th anniversary of Linnaeus's birth, for no Swede, whatever his profession, could neglect such a national hero: "Here, man is no longer the center of the world, only a witness, but a witness who is also a partner in the silent life of nature, bound by secret affinities to the trees."

The history of science is studded with monumental egos, but none holds a candle to Linnaeus. I doubt that anyone before Muhammad Ali surpassed Linnaeus's own third-person assessment from one of his several autobiographical documents.

> God has suffered him to peep into his secret cabinet.



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None before him has so totally reformed a whole science and made a new epoch.
None before him has arranged all the products of nature with such lucidity.

Arrogant, yes. But note that the cabinet is God's and the products thereof. If someone with an ego so unbounded still stated that he had only discovered God's order, not constructed his own from the transcendent brilliance of his unique psyche, then I must suppose that he truly embraced the idea of natural order independent of the human mind (even at its Linnaean apogee). I would be suspicious of such protestations from a more modest man.

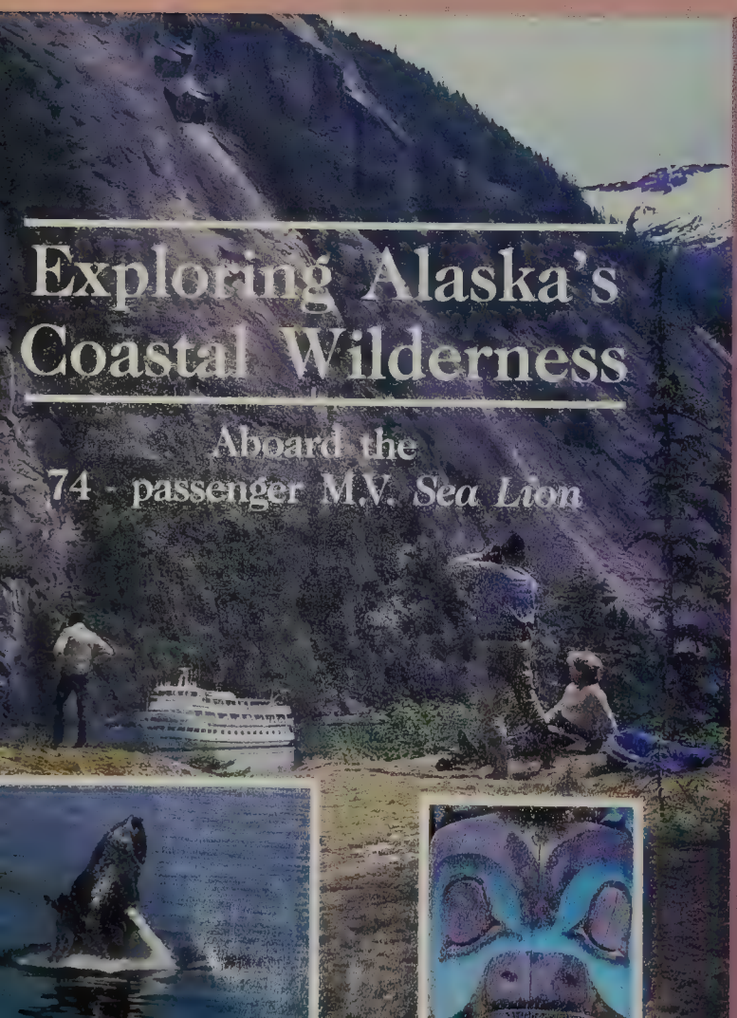
In practice, Linnaeus classified his plants by the form, number, and arrangement of their organs of fructification—the so-called sexual system. Basically, he divided plants into classes by the number and position of stamens, and he then divided classes into orders by the number of pistils. Ironically, he knew that such a system must be artificial—an almost numerological imposition of human logic upon nature's greater complexity. All his life he searched for a *methodus naturalis,* or natural method, to capture God's objective arrangement in his hierarchy of names—and he never succeeded. A solution to this problem awaited the second unmasker, for no rational order of divine intelligence unites species. The natural ties are genealogical connections along contingent pathways of history—and such ties, although recoverable once you know the system, do not fall into patterns of beautiful symmetry or complex geometry that creationists like Linnaeus anticipated, and therefore could never find. Remember that the masks discussed in this essay are not camouflage that nature places over her products, but impediments that we construct with false theories.

Since this is an essay about connections, I must end with one of the most striking of all meaningful coincidences. Where did the second unmasking begin: Where did the world first hear the sounds of Darwin's revolution? London, yes, for Darwin became a homebody after his *Beagle* voyage and never crossed the English Channel. But where in London?

When Linnaeus's son and succes died in 1783, his mother and sisters cided to sell the great collection—spe mens, cabinets, books, letters, and ma scripts—to the highest bidder. They w purchased by James Edward Smith young English naturalist and son of a r manufacturer in Norwich, for the incr ible bargain price (even by eighteen century standards) of just over a thousa pounds.

We must now consider one last Gus vian connection. The king was in Italy a France during hurried negotiations that to the sale. Many historians speculate th had he been in Stockholm and known plans to deport such a national treasure, would probably have intervened (esp cially since a Swedish buyer had be found, but only after the sale had be legally concluded). The most famo nineteenth-century Swedish biography Linnaeus states: "Had he [Gustav] be informed in proper time it is certain that would have strongly exerted himself a rescued these precious collections for t fatherland, especially when one consid his care for Sweden's honor, and the gr admiration he entertained for Linnaeu

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ccording to one apocryphal tale—actu-
y no more than a persistent rumor—
ustav III dispatched a warship to inter-
pt the brig that had already sailed with
nnaeus's collections on board, but the
ig had too great a head start and reached
ndon safely.

In any case, Smith treasured the collec-
ons all his life and kept them in good
der. When he died in 1828, they were
ought by a fledgling organization called
e Linnean Society of London. The col-
ctions still form the shrine and center-
ece of this organization, Britain's fore-
ost society for the study of natural
story. They reside in Burlington House,
ght on Piccadilly in the center of Lon-
on. I once visited this shrine and work-
ace for a consummately practical reason.
innaeus himself named the type species
f the genus of snails that forms the sub-
ct of my technical research. This species,
erion uva, comes from Curaçao, and I
anted to make sure that Linnaeus's spec-
nen truly represents this distinctive
ecies. I was ushered into the vault of the
oly of holies and shown the specimen.
innaeus was right again; it is *Cerion uva*
om Curaçao.

When Charles Darwin received Wal-
ce's manuscript from Ternate, and real-
ed that his younger colleague was about
scoop twenty years of work on natural
election, he appealed to his friends to find
me honorable way that would recognize
oth his priority and Wallace's discovery.
is friends proposed a joint presentation
f Wallace's paper with some of Darwin's
arlier, unpublished writings. Darwin did
ot attend this meeting in 1858, for he was
home mourning the death of his young
on. But the meeting was held in Lon-
on—at the rooms of the Linnean Society
the building that housed Linnaeus's own
ecimens. The joint papers were pub-
shed in the 1858 volume of the *Proceed-
gs of the Linnean Society of London.*

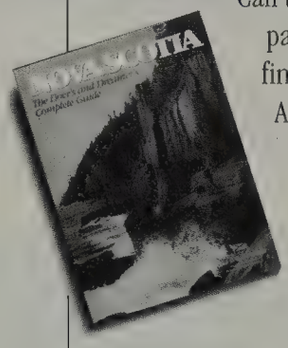
Thus did the second unmasking begin
the transposed home and living pres-
nce of the first—and the ghost of Lin-
aeus smiled (being more generous and
cumenical than the great Swede in life) as
Darwin's words revealed a causal basis for
he natural order that Linnaeus had codi-
ed. And the psalmist intoned his ancient
ong: "Behold, how good and how pleas-
nt it is for brethren to dwell together in
nity!"

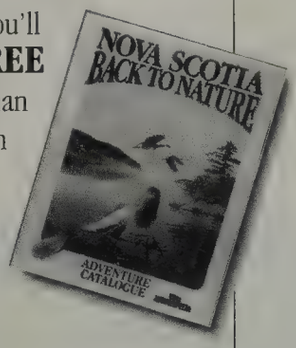
*tephen Jay Gould teaches biology, geol-
gy, and the history of science at Harvard
Jniversity.*

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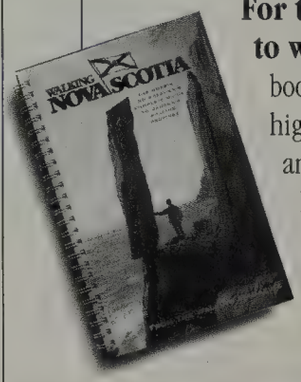
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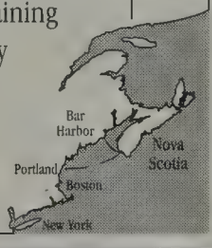


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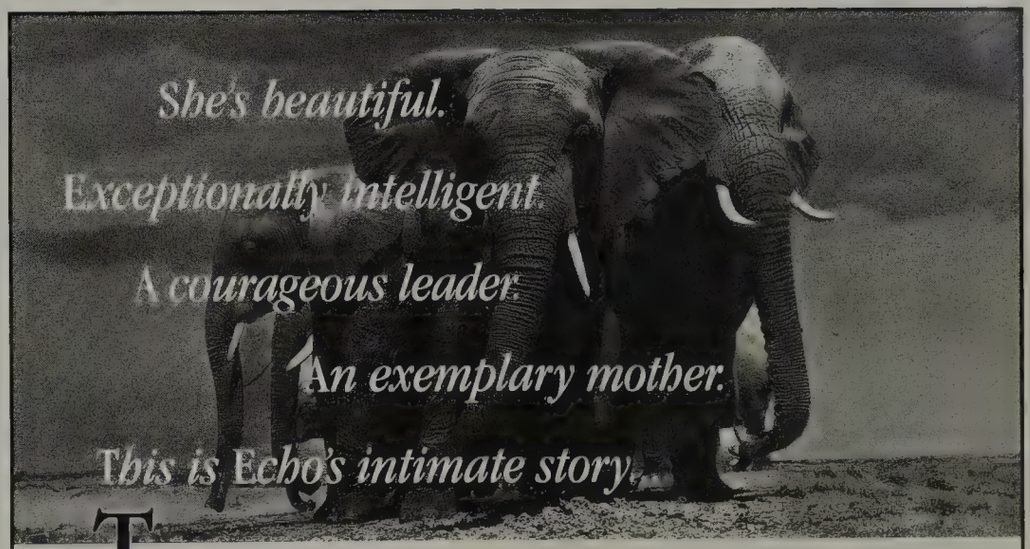
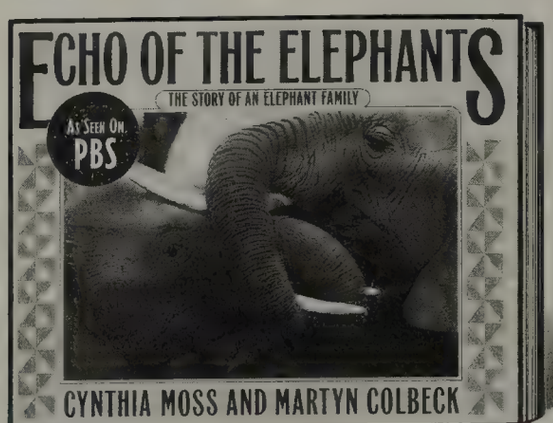


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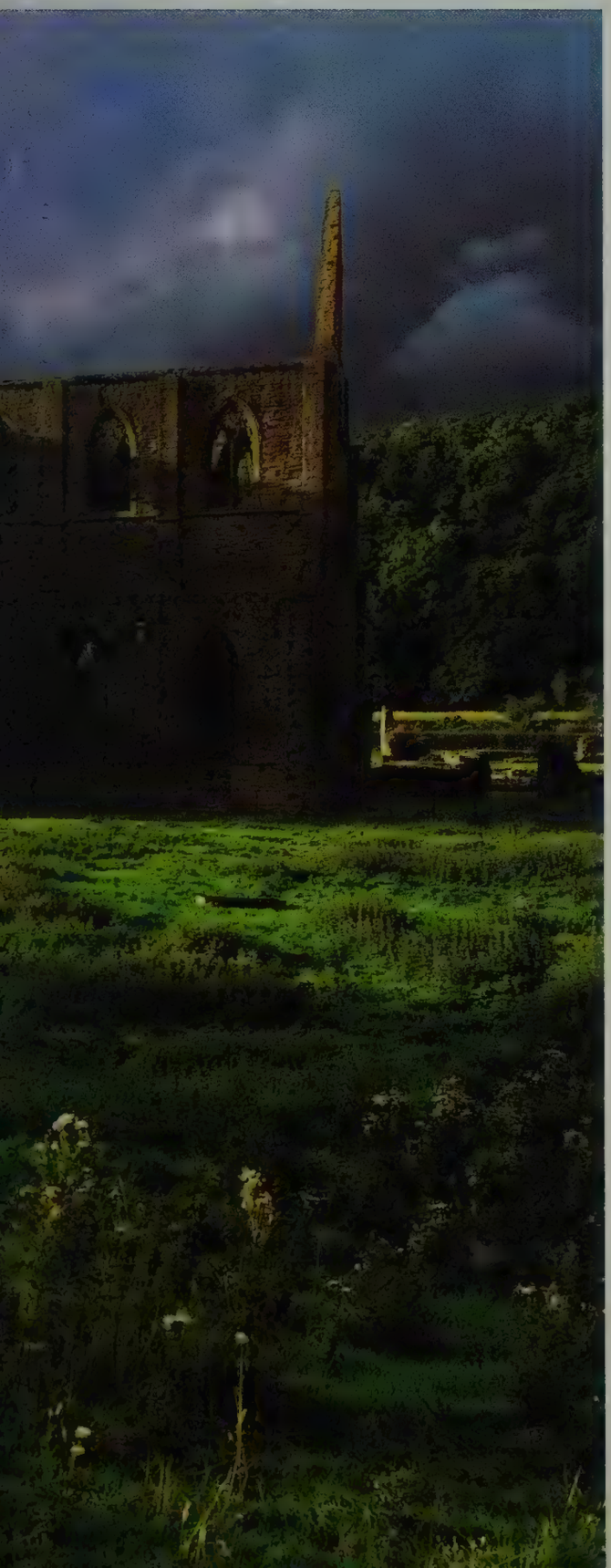
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Simpson Township Barrens, Illinois

by Robert H. Mohlenbrock

Eight summers ago, while driving along country road through Shawnee National orest, just north of the tiny village of mpson, Illinois, botanist Max Hutchison the Nature Conservancy noticed an oc- sional purple coneflower and butterfly ilkweed blooming along the roadside at e edge of the woods. These two plants do t usually grow in forests but in prairies d glades, open habitats with few trees. ater, when Hutchison and Forest Service gional botanist Lawrence R. Stritch alked into the dense upland forest adja- nt to these wildflowers, they found that contained primarily post oaks, chin- apin oaks, and eastern red cedar, with a arse understory of woodland herbs. The rple coneflower and butterfly milkweed d not grow under the trees.

A check of the first government surveyor's report for the region, from the 1830s, turned up the term "barrens" applied to some parts of the Simpson area. Today, barrens refers to a forest area where prairie plants grow beneath a canopy of sparse, usually stunted trees. Botanists have not used that term to describe a natural community in Illinois in this century. We do not know what these early surveyors were looking at, but it was obviously not the closed forest we see there today. To test whether more open conditions would encourage the growth of purple coneflower, butterfly milkweed, and other species that may have been present in the former barrens, Stritch proposed subjecting a patch of the forest to some drastic management.

In the fall of 1987, six acres of the forest were thinned of the large, misshapen trees, called wolf trees, spared during past logging operations because of their minimal commercial value. Only the healthiest post oaks were left. In all, thirteen cords of wood were removed. And in the early spring of 1988, a fire was set and allowed to consume the leaf litter that had built up during the past decades. Such fires retard the growth of and eventually kill the shrubs that live beneath the forest trees.

Within weeks, as the new growing season got under way, prairie grasses, including big and little bluestems and Indian grass, began to spring up throughout the burned-over area. Purple coneflowers and butterfly milkweeds increased manyfold, flourishing even beneath the remaining trees. Rosettes of leaves came up everywhere; most were perennials, not mature enough to flower and thus be identified in



rairie plants crowd newly created barrens, above, at the end of October. Periodic fires ill help maintain this habitat. Left: purple coneflower, a typical prairie plant.

thy Clay

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Purple milkweed is one of more than 200 species to appear in the barrens.
Rob and Melissa Simpson

1988. The seeds for some of these plants may have been lying dormant in the soil for years; most were probably blown in from the limestone glades that dot the upper slopes in the vicinity.

Botanists eagerly awaited the 1989 growing season to see the transformation

Simpson Township Barrens

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(618) 253-7114

continue, and many local groups and in viduals, caught up in the project, volu teered their help. The boy scout troop co structed a split-rail fence to mark off area, the county highway department nated and installed a new culvert to div drainage water from the road away fr the project, inmates from a nearby corr tional center cleared the debris that had sulted from the tree cutting, and the Nat Conservancy donated funds to purcha needed equipment. For its part, the For Service offered the thirteen cords of wo removed from the area as free firewood the local residents.

The spring of 1989 brought one ple ant surprise after another as the barr community took shape. Mead's sedge prairie species with bluish leaves and sl



r rhizomes, found a niche and spread out
er an area of about ten square feet. Pink-
n purple flowers of the hairy phlox con-
ısted brilliantly in May with the orange-
llow blossoms of hoary puccoon. Low
ımps of bird's-foot violets, not recorded
ǒm the Simpson area previously,
ounded. In the vicinity of exposed lime-
ɔne pebbles, colonies of marbleseed ap-
ared for the first time. A three-foot-tall
rb whose leaves and stems are covered
short, stiff, silver hairs, marbleseed pro-
ces inch-long, tubular, creamy flowers
llowed by shiny, pearl-white seeds.

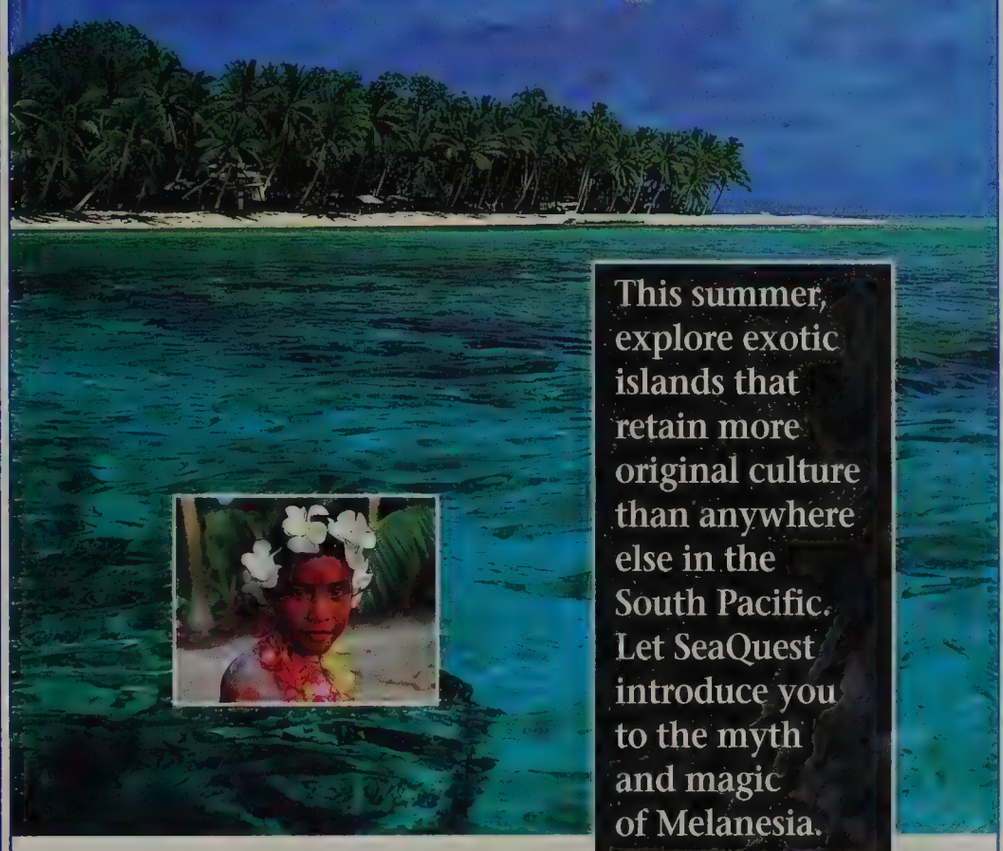
By summer, the barrens contained a riot
colorful wildflowers, including purple
ilkweed, yellow coneflower, showy rud-
ckia (a type of black-eyed Susan), and
berous Indian plantain. Autumn brought
rth the yellows of prairie rosinweeds,
nflowers, and goldenrods, and the pur-
es and whites of numerous kinds of
ters, as well as several typical prairie
asses. Prairie rose, a common, low-
owing shrub, bore two-inch-wide pink
ɔwers from June through September.

Across the road from the barrens is an-
her post oak woods with barrens species
the fringes. The soil is more acidic
ere because of the chunks of sandstone
at fall from fifty-foot cliffs above the
oods. Six acres of this woodland were
so burned in 1988, but few trees were re-
oved. The burning has resulted in an in-
ease of shade-tolerant, acid-loving
ecies, including Enslen's blackberry
esignated an endangered species by the
ate), the rare shrubby evening primrose,
d several other species that had not been
corded before from the area. Beyond the
ırned area, where the post oak woods
ope down to a rocky creek below this
cond barrens, heart-leaf plantain and the
perb lily grow. Heart-leaf plantain, cur-
ntly being considered by the U. S. Fish
d Wildlife Service for listing as an en-
angered species, is one of the rarest
ants in the country, while the superb lily
another species designated endangered
y Illinois.

Stritch and his colleagues burned both
arrens again in the spring of 1990, and
e considering another burn in the near
ture. Each year, more plant species are
scovered in the barrens: the total already
xceeds 200.

*obert H. Mohlenbrock, professor emeri-
s of plant biology at Southern Illinois
niversity, Carbondale, explores the bio-
gical and geological highlights of the
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Der Ring des Bubbalungen

Borrow unto others before they borrow unto you

by Roger L. Welsch

It was the day that you skipped class thirty years ago to have coffee and a doughnut with that cute sophomore in Intro to Anthro. I didn't have a chance with her, even with a chocolate doughnut, so I went to class. And that was the day Cro-Magnon Christensen bored us with his lecture about Bronislaw Malinowski's study of the Trobriand Islanders' Kula Ring. The Trobriand Islanders—get this!—trade red-shell necklaces clockwise around the Pacific islands and white-shell armbands counterclockwise along the same route. The goal is to accumulate more and more armbands and necklaces and thus more and more prestige, the shell jewelry having no value other than prestige. I can't recall what Malinowski concluded, but C-M Christensen used it as an example of how arbitrary human behavior can differ from one culture to another.

He was wrong. In the intervening years I have been struck again and again by how much alike we are—us and them, Americans and less reasonable people, penny-stock shufflers and Kula Ring runners. Malinowski could have saved a lot of trouble and transportation costs by coming to Nebraska. This realization came to me after a long period of serious observation, which pretty much lets Malinowski off the hook, since he didn't spend a lot of time in Nebraska. Here it's not the Kula Ring but the Bubba Ring, the big difference being that the Bubba Ring involves not worthless shells but objects of real value. Otherwise the object of the two social systems is pretty much the same: do unto others before they do unto you.

Woodrow Buehler and I were at an auction last week when a six-foot iron pry bar went on the block. Woodrow is constantly borrowing my pry bar because in his business—plumbing and salvage—a pry bar is the sort of thing you need every day. That means Woodrow borrows my pry bar on a regular basis. Then I go back over to his place and get it back, and then he comes here and borrows it, and so on.

The pry bar at the auction drew an initial bid of twenty-five cents from Stan Kowalski, who opens every bid with an offer of twenty-five cents, whether the object in question is a mint 1957 Chevy hardtop with 12,000 actual miles on it or a five-gallon bucket of used firecrackers. This time the bid stuck at a quarter for a full minute while the auctioneer begged for a dollar. "Fifty cents," Carl Kohl yelled. Another long pause.

I poked Woodrow. "That thing is going to bring less than two bucks." No reaction.

"Buck!" muttered Stan. Woodrow rocked on his heels.

"Woodrow, what are you waiting for?" He looked at me as if I had just suggested he slash his wrists or go back to school.

"Buck fifty!" crowed Carl.

"Going, going, going…GONE! Buck fifty to Carl Kohl."

I sputtered to Woodrow, "You could have had that bar for the price of a beer."

"Why…" he paused. "Why would I buy a pry bar when you already own one?"

Bubba Ring Rule 1: There is no need for two people to each own something like a pry bar.

I understand borrowing a six-foot iron pry bar: It just sits in my shed until Woodrow comes by to pick it up again, but the issue isn't always that clear. For example, Woodrow owns a canoe, but he doesn't own paddles. Paddles, to my mind, are an integral part of a canoe. Would you have a rod and reel and borrow fishing line? A road and borrow gravel? No. But in the Bubba Ring, this is a common logic.

I once showed Woodrow and our mutual buddy Lunchbox a filter I had installed in our water line. As water comes from our well, it passes through the filt which removes ugly-bugglies, if you c excuse the technical terminology. C water tastes fine, is healthful, and longer requires chewing. Since Lunchb has the same problems with his wate thought he would be interested in the filt and since Woodrow is a plumber, I thou it might strike his fancy, too.

Lunchbox was interested; Woodr was fascinated. "That thing is fantasti Woodrow enthused. "Lunchbox, y ought to borrow it."

Woodrow had just proposed that I le out part of our plumbing! When I regain my composure, I was flabbergasted. I claimed, "Woodrow, you're dense as a nut!" Woodrow and Lunchbox were bo shocked by my small-mindedness.

Bubba Ring Rule 2: Nothing is beyo borrowing.

My arrival in Dannebrog twenty ye ago generated some comment—for exa ple, "What a dufus!" Thing is, I listened my father, who to this day says, "Ne borrow anything, and when you do, retu it in better condition than when you it." I love my dad, but he doesn't know about the Bubba Ring.

Slick once asked me to come up to house and help him trim some trees har ing over his garage. "Sure," I said.

"Bring along your saws," Slick sa "And your ladders. And your tractor. A ropes and chains."

Uh-oh—the Bubba Ring! I thought t I might avoid the inevitable complicatio of the Bubba Ring Syndrome by not l ting my tools out of my sight. That w when we finished the job, I'd just bring stuff home with me. Such innocence was lucky to leave Slick's place with tractor and pants. He wound up with ladder, ropes, chains, and saw, which I not see again for three years.

The only reason I ever got any of my tools back is that Slick moved. Friends offered to help him, but he smiled with total self-confidence and said that he wouldn't need help. All he had to do was tell everyone to come get the stuff he had borrowed over the past twenty years and he could move what was left in a cardboard box.

Bubba Ring Rule 3: You can save yourself the trouble of returning things in good condition by not returning them at all.

Slick did what he said he was going to do. I got my saw, chains, ropes, and ladder and a lot of other stuff I had almost forgotten. A week later, Slick asked me to come and help him trim some trees that were rubbing the shingles of his new house. I said I was busy, but that didn't work. "Okay, Woodrow and I will come over and pick the stuff up. Bet you don't even have it out of your pickup truck yet."

I didn't. When I mumbled that I hadn't had my tools long enough to get reacquainted with them, even Slick had to agree. "Hmmm," he said disapprovingly. "I was hoping you would replace the bad rope on our block-and-tackle and sharpen the chain on our saw."

Bubba Ring Rule 4: Possession may be nine parts of the law, but the tenth part, repair and replacement, is the owner's responsibility.

And what's that stuff about "our" block-and-tackle, "our" saw?

Bubba Ring Rule 5: If you had trouble with the community property ruling in your recent divorce, don't even think about getting involved in the Bubba Ring!

Last week I witnessed a raging argument between Slick and Russell Barker. When Slick got married a few years ago, he borrowed Russell's good shoes and never got around to returning them. "You stupid, no-good, irresponsible deadbeat!" Russell roared into Slick's face. "I want my shoes back, and my bowling ball, and bicycle, and hedge trimmer."

I expected fury but Slick was neither angry nor hurt. He was indignant. Russell was violating the rules of the Bubba Ring. "No matter how nasty you get, Russell," he said, "You're not going to make me mad enough to give your stuff back."

Bubba Ring Rule 6: The customer is always right.

As in the Trobriand Islands, Bubba Ring exchanges are a matter of prestige and strategy, not value and commerce, and I haven't lived out here all these years without learning a little about how things are done. This morning, for example, Woodrow stood in our farmyard kicking gravel and sucking his coffee, finally asking, "You still got the posthole digger I saw in your shed last summer?"

"Uh, I lent it to Kenny Price when he was building a fence this spring." I pawed casually through the rubble in the box of Woodrow's pickup.

"Isn't that the handle I see over there in the corner of the shed?" he said, trying to draw my attention away from his white armband shells.

"Well, look at this! Here's my torque wrench," I said, trying to divert his gaze from my red necklace shells.

"By golly, that *is* your posthole digger!" He moved toward the shed. Should I defend my territory or launch a threat against his? I tried both: "Hey, Woodrow, I need to borrow this set of socket wrenches of yours for a couple days," and I moved briskly toward the shed to head off his shopping expedition.

"Yep, here it is—the posthole digger and a minnow trap! I'm setting catfish lines tonight. I'll bring you fish by morning, wait and see!"

"Uh, Woodrow, I need the furniture dolly you borrowed two years ago."

"Why?"

"We're moving the fridge."

"Did you get a new fridge?"

"Uh, why?"

"I was thinking maybe I could borrow your old one for a bait cooler."

"Well, I am going to, uh, put the old one in my shop...and besides, I need my rake back because, er, after we redecorate the kitchen, we're starting on the lawn."

"Look at this! A tiling spade! Just what I need for...." I was losing ground.

Bubba Ring Rule 7: A beginner always loses ground.

Eventually I suspected that I was being watched. I'd buy a wheelbarrow in Rising City and two days later, there was Slick, wanting to borrow a wheelbarrow. I'd buy a rasp and the next day Woodrow needed a rasp. I couldn't wear the labels off of new tools if I waited more than three days to use them.

I learned later that Woodrow's wife's cousin Faye, Slick's daughter-in-law, works at the bank and in casual conversations with her favorite cousin she'd drop nuggets of information like, "Gosh, Bernice, the girl next to me was clearing checks yesterday, and she goes, 'Here's one from that Welsch guy, and he paid, get this, fifty smackers for a wheelbarrow!' "

Bubba Ring Rule 8: There's no hiding place.

This, obviously, is research in progress.

(Postscript: I did finally locate my furniture dolly. Woodrow lent it to Kenny, who lent it to Slick, who lent it to his mother, who lent it to Reverend Miller, who lent it to Dave Calvin, from whom, it turned out, I had borrowed it originally twenty years ago. I'll probably never get it back now.)

Folklorist Roger L. Welsch lives on a tree farm in Dannebrog, Nebraska.

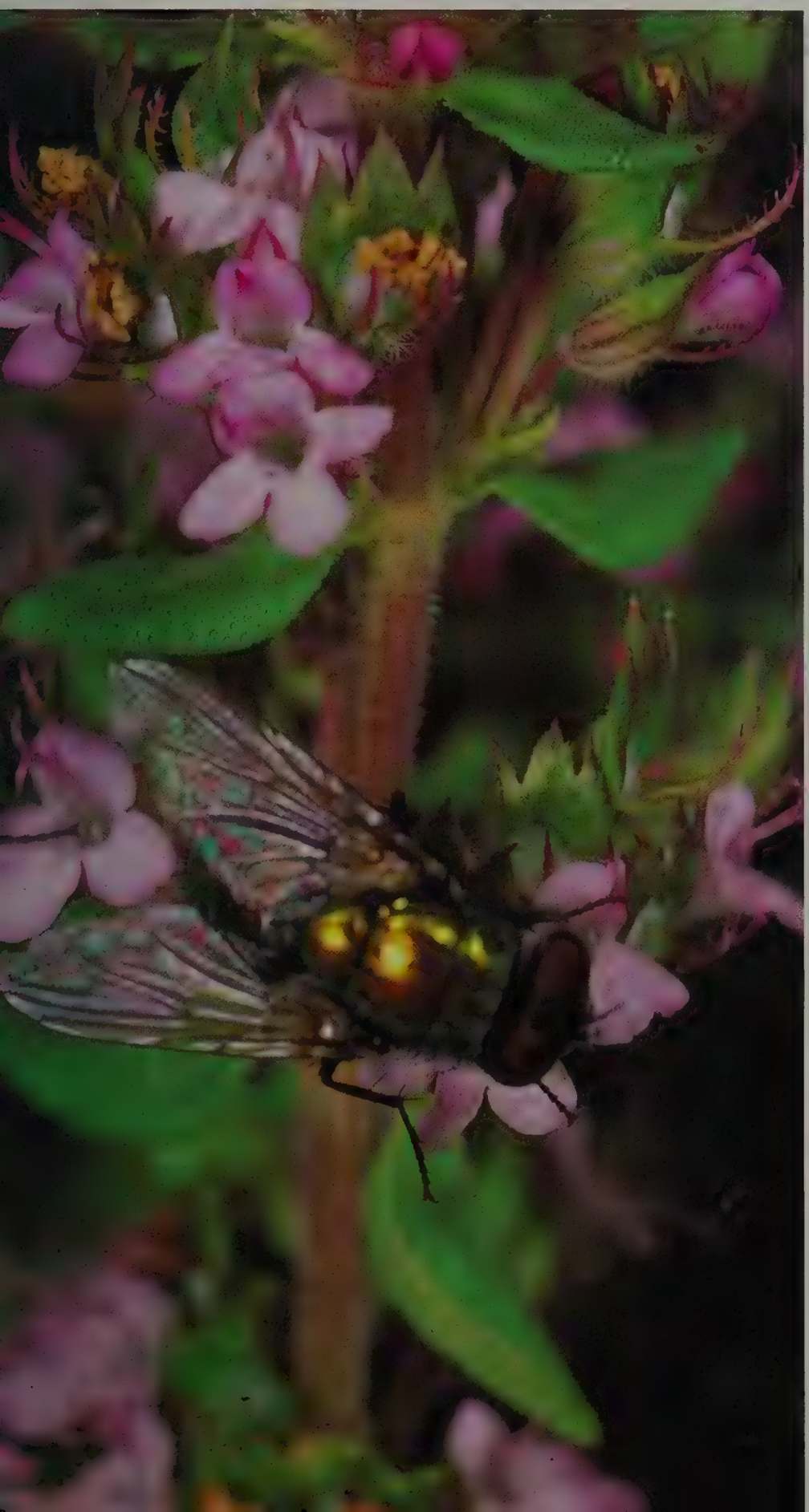
Australian blowflies use their tubelike mouthparts to suck up nectar.
C. A. Henley



Pistil-packing Flies

In exchange for a meal of nectar and pollen, many flies prove accomplished pollinators

by Carol A. Kearns and David W. Inouye



Early July in the West Elk Mountains of Colorado. The meadows around the old ghost town of Gothic, now the site of the Rocky Mountain Biological Laboratory, are a riot of wildflowers. Bumblebees, butterflies, and flies flit among the blossoms with biologists in solemn pursuit. Amidst the hue and hum, we are cataloging the flies that visit the wildflowers, documenting how often we see each species of fly, and monitoring the insects' movements among the various flowers. After several years of work at two field stations 9,500 feet high in the Colorado Rockies, we have come to appreciate the importance of these understudied pollinators: our records show that more than 130 species of flies visit 66 species of wildflowers in our study area and that for many of these flowers, the flies are significant pollinators. We once counted as many as 1,200 pollen grains on the body of a single fly.

Flies have neither a beak nor a long tongue with which to extract nectar or pollen, and their short, tubelike mouthparts, designed primarily for sucking, are most efficient on shallow, bowl-shaped flowers. Among the numerous montane plants with fly-friendly flowers are lovage, mountain parsley, cow parsnip and other species in the carrot family; cinquefoil and others in the rose family; and bitter cress in the mustard family. Even some members of the sunflower family, such as the aspen sunflower, fleabane, and groundsel, are attractive to flies, despite the reputation these plants have as being archetypically bee-pollinated.

Traditionally, when flies are thought of as pollinators at all, it is in association with tropical "carrion" flowers. These flowers produce an odor similar to that of rotting meat and attract female flies seeking a carcass on which to lay their eggs. Once they discover their mistake, the flies depart, carrying with them loads of pollen and—if they are deceived again—perhaps delivering the pollen to other carrion flowers. The mountain flowers we study, however, do not fit this rotten stereotype at all. Most employ the same attractive colors and scents that lure bees and butterflies and



Bill Johnson

Australian March flies, below, feed primarily on blood, but also take an occasional nectar meal, as this fly is doing on a shrub in the myrtle family. A hover fly, left, eats pollen. This protein-rich food source is important to the females of many species for the development of eggs.

David W. Inouye



dutifully reward their visitors with pollen and nectar.

Unlike the social bumblebees, flies do not collect pollen to take back to a hive. However, many species of flies are avid pollen eaters. (The sucking mouthparts of a fly, with a fleshy, maneuverable pad at the tip, can also be used to pick up and swallow pollen grains.) Females of these species seem to require large amounts of this protein-rich resource prior to developing their eggs. In fact, some of the plants attractive to flies produce no nectar at all, only pollen. In experiments with one such plant—the elderberry bush—we found that hungry flies collected all the available pollen from the flowers by midmorning each day.

Fortunately for the plants, not all the pollen wound up in the flies' stomachs. Pollen grains often have a sticky outer layer that helps them adhere to the bristles or various parts of a fly's body, and these grains can then be transferred to the receptive stigma of the same or another flower. Confirmation of these insects' role as pollinators came when we covered the elderberry flowers with netting to prevent visits by flies. Covered plants produced no seeds, while plants visited by flies bore many fruits with seeds. On some other plants, like flax and cinquefoil, the common fly visitors move from anther to anther within a flower, ingesting pollen, and then dip down into the nectary for a little something to drink.

Pollen grains would seem a somewhat difficult diet. The grains are too small to be chewed (and flies have no chewing mouthparts anyway), and the exine, or shell, of a pollen grain is indigestible. Exines are so resistant to strong acids and bases that solutions of these substances are commonly used to clean pollen grains in preparation for examination under a microscope. This indestructibility is what renders pollen grains such valuable indicators of past climates; grains in core samples extracted from lake beds, for example, where the pollen may have lain for thousands of years, can tell scientists what kinds of plants flourished at various periods in the past.

The nutrient-rich contents of the pollen grains are released, however, when the grains are soaked in a solution of sucrose, which happens to be one of the common sugars in nectar. So, by immersing the grains in the nectar within their digestive tracts, the flies can extract the protein they require. We have found that after pollen grains pass through a fly (a thirteen-hour process), the exines are usually empty, indicating that pollen is indeed a source of

David Jensen

Elderberry flowers visited by muscoid flies, below, produced seeds, while flowers covered with protective netting did not: proof that the flies do more than eat the pollen; they also serve as pollinators. Like many mountain wildflowers, a field of flax blooming in the shadow of Wyoming's Grand Tetons attracts both flies and bees.

David W. Inouye



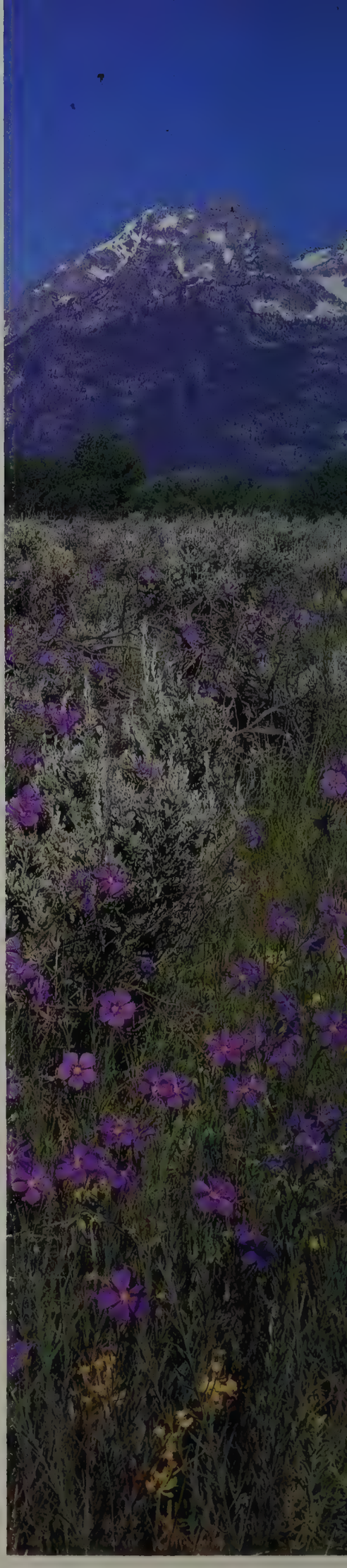
nutrition for the flies. A study of exines retrieved from a fly's gut or feces can reveal what flowers the insect has been visiting.

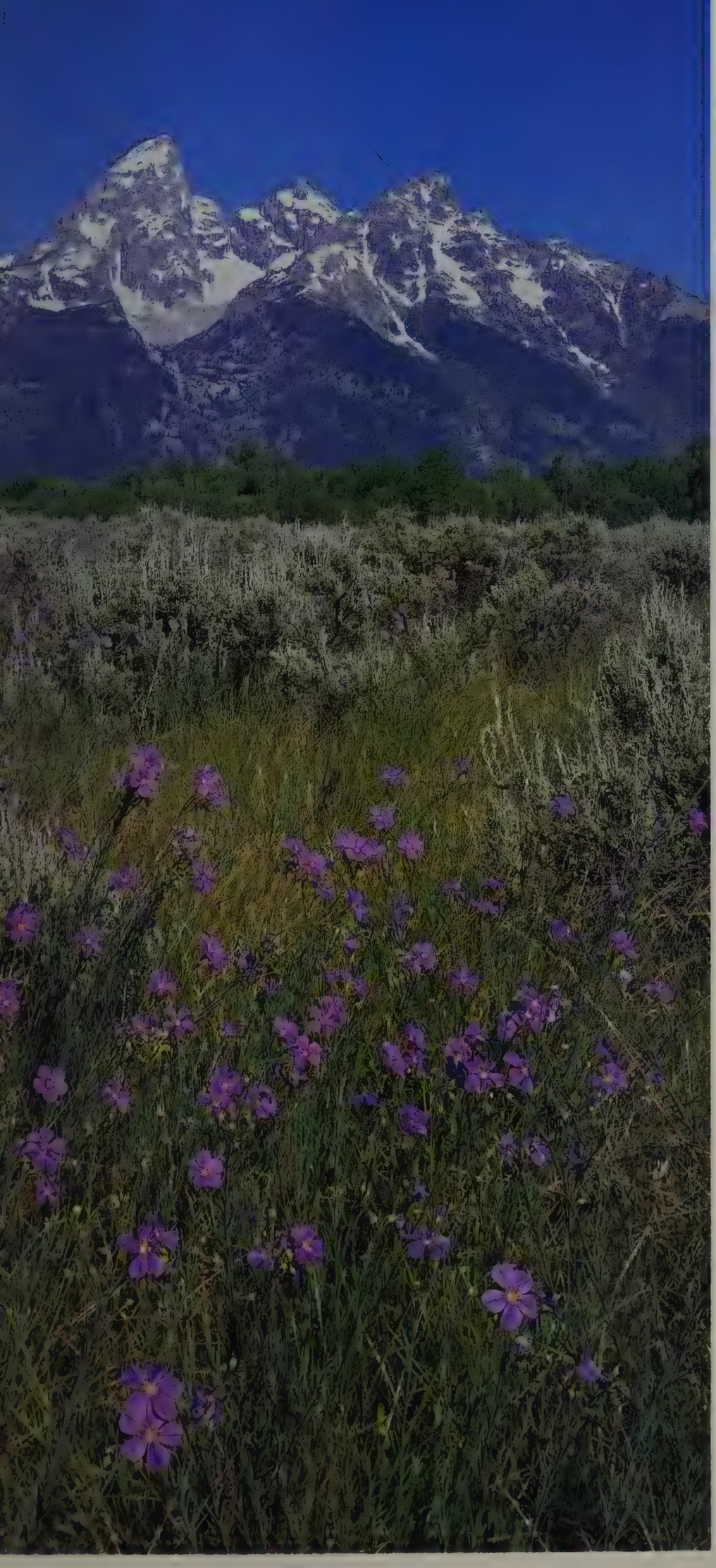
Another attraction of some flowers may be warmth. In order to fly, most flies must have a thoracic temperature close to that of the human body (98.6° F). A few species of flies are able to generate this heat themselves by exercising their flight muscles, but most are more passive, simply basking in sunlight until they are warm enough to fly. In cold environments, however, this can take a while, and in such places, plants can be a help. Several alpine and arctic flowers are shaped like solar reflectors, and some even track the sun during the day, bending on their stems to receive maximum light. Temperatures inside these flowers have been measured at 12° to 14° F above the surrounding air temperature, while flies basking in them can reach temperatures 27° to 29° F higher than the air. This elevated temperature may enable them to begin their daily foraging earlier; it also speeds metabolism, allowing digestion and egg development to proceed more rapidly.

Some mountain flowers also serve as "singles bars" where flies gather to meet members of the opposite sex. A search for flies on cinquefoil flowers, for example, is as likely to turn up mating pairs as lone individuals sipping nectar or eating pollen. This behavior, not surprisingly, is not unique to flies. Most solitary bees and many beetles also mate on pollen-bearing flowers.

Some strikingly colored flies visit Rocky Mountain flowers, but we have been particularly interested in the common, relatively plain muscoid flies. These flies, a collection of species from several closely related families, resemble houseflies. They are generally gray or black (a few are metallic blue or green) and sport stiff bristles on their bodies. Many of the muscoid flies are so similar in appearance that taxonomists rely on the position of bristles to tell species apart. Since bristles often fall off prepared specimens, this may mean searching for a tiny spot indicative of the lost bristle. In our fieldwork, we can usually only identify muscoid flies to the level of the genus or family; for species identification, we must rely on collected specimens.

Several of the muscoid genera—*Thricops, Phaonia, Spilogona,* and *Drymeia*—are typical residents of high mountains and boreal regions around the world. Larvae of muscoid flies develop in wet humus and are generally carnivorous, eating other





small insects. In the Colorado Rockies, the more conspicuous adult forms emerge in the early summer as the snow melts and flowers begin to appear.

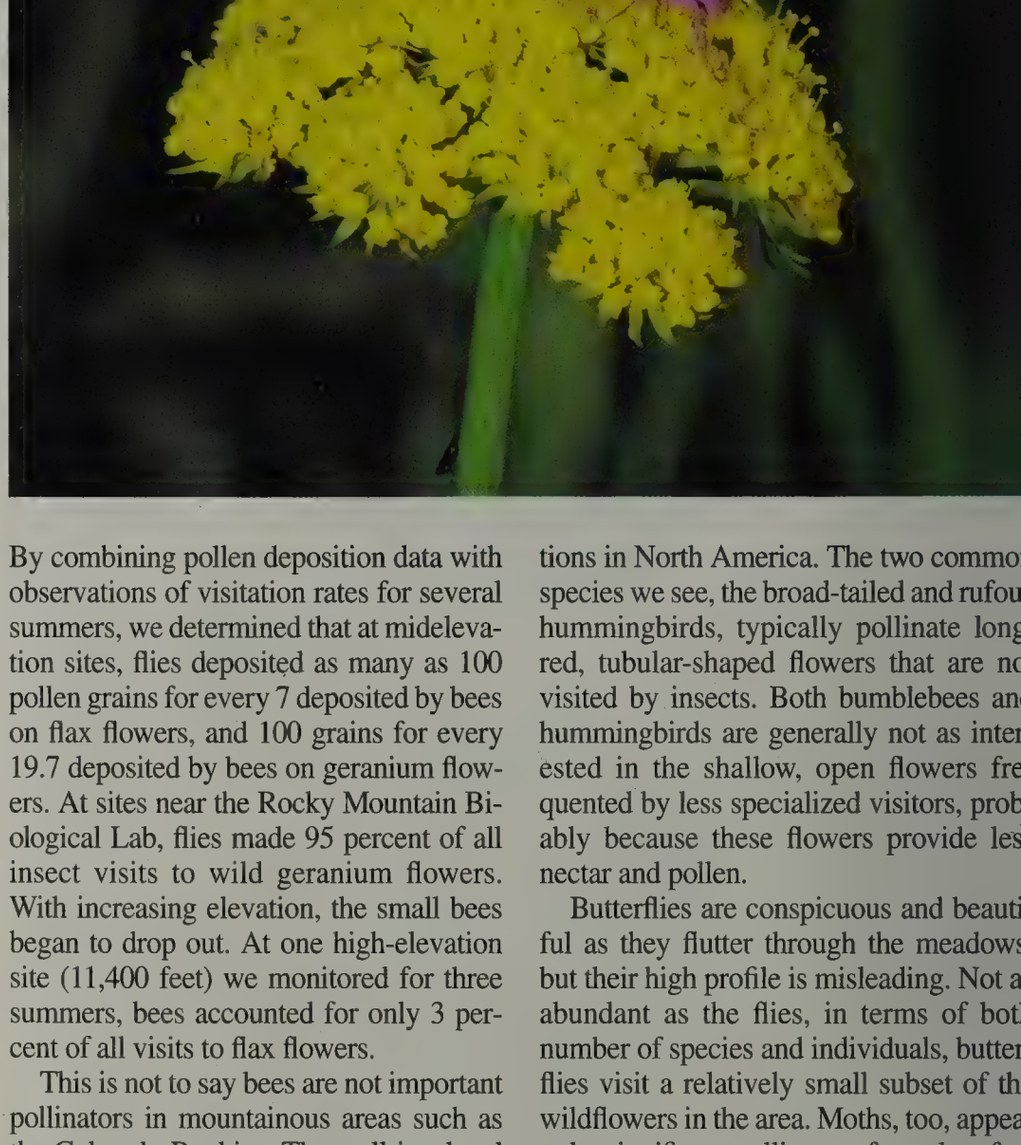
Flies have a reputation among pollination biologists for inconstancy, visiting many species of flowers. This sort of behavior can be disadvantageous to plants, since it reduces the likelihood that pollen will be transferred from one flower to another of the same species. To test whether flies deserved their reputation, we studied fly foraging in the field. To see and recognize individuals better, we dusted flies with fluorescent pink, yellow, and orange powders and then watched the colored insects moving from plant to plant. We discovered that most of the time, flies flew from one plant to an adjacent one of the same species. (In part, this may be because a single plant species often dominates a given small patch of ground.)

Both flies and small bees did fly to different plant species sometimes, but flies did so no more often than bees. There was one way, however, in which foraging bees and muscoid flies differed markedly. The flies spent long periods visiting individual flowers, grooming and resting between feeding bouts. On some occasions, resting in flowers appeared to be a response to low air temperatures and cloud cover. When clouds temporarily blocked sunlight, for instance, flies often remained in flowers or occasionally even walked onto nearby vegetation. Then, several seconds after the clouds passed, they resumed flying. In contrast, bees flew directly to the next flower without pause (although on cool or overcast days, small bees, which cannot thermoregulate like the bumblebees, were absent). The explanation for the difference is that while female bees must provision a nest and therefore have no choice but to keep on the move, muscoid flies are foraging just to feed themselves.

The flies' tendency to spend a fair bit of time in a single flower (much longer than bees do) probably has consequences for the plant as well. As a fly meanders from anther to anther within the same flower, it

Muscoid flies are normally drab; the fly below, on a mountain parsley flower head, was dusted with fluorescent powder to help researchers track its movements. With their short tongues, flies, like the hover fly at right, tend to visit shallow, open flowers.

David W. Inouye



is likely to transfer many pollen grains to the stigma, the sticky, receptive part of the pistil. In self-compatible flowers (that is, flowers able to pollinate themselves), these grains may germinate and eventually fertilize ovules. We are currently interested in determining whether flax populations pollinated predominantly by flies have higher levels of inbreeding than do bee-pollinated populations.

Watching muscoid flies for a brief period—as they travel short distances between adjacent plants and spend a relatively long time on them—an observer might get the impression that they don't cover much ground. In reality, however, the distances they move between flower patches in a day may exceed those of bees, which restrict their foraging to areas around their nests. We released marked flies in cinquefoil patches and found that after fifteen minutes, most had flown out of sight. Of the hundreds of flies we marked and followed with the help of Earthwatch volunteers, only one was resighted the next day. The conclusion we draw is that flies move pollen (and the plant genes they contain) much farther than bees do.

Two species of flowers that attract flies are the wild blue flax and wild geranium. These flowers are also visited by bumblebees and the smaller, solitary andrenid, halictid, and sweat bees. To determine which insects were more important as pollinators, we collected the stigmas of flowers after a single insect visit and examined them under a microscope for the presence of pollen grains. In general, the big bumblebees transferred the most pollen in a single visit; an average of twenty-seven grains were deposited on flax flowers by bumblebees, compared with sixteen grains deposited by small solitary bees, thirteen by muscoid flies, and seven by syrphid, or hover, flies. On geranium flowers, an average of ten grains were deposited by bumblebees, compared with four by small bees, three by muscoid flies, and two by syrphids.

However, the amount of pollen transferred at one time is not the whole story. By combining pollen deposition data with observations of visitation rates for several summers, we determined that at midelevation sites, flies deposited as many as 100 pollen grains for every 7 deposited by bees on flax flowers, and 100 grains for every 19.7 deposited by bees on geranium flowers. At sites near the Rocky Mountain Biological Lab, flies made 95 percent of all insect visits to wild geranium flowers. With increasing elevation, the small bees began to drop out. At one high-elevation site (11,400 feet) we monitored for three summers, bees accounted for only 3 percent of all visits to flax flowers.

This is not to say bees are not important pollinators in mountainous areas such as the Colorado Rockies. The well-insulated bumblebees seem especially suited for the job and are distributed over the whole altitudinal range. But, by and large, their taste in flowers differs from the flies'. The dozen species of bumblebees in our study areas, for example, usually visit flowers with nectar concealed in moderately long corollas. The long corolla tube keeps short-tongued insects such as flies from taking the nectar and pollen and thus insures a large reward for the bee.

Hummingbirds are another well-known group of pollinators found at high elevations in North America. The two commo species we see, the broad-tailed and rufou hummingbirds, typically pollinate long red, tubular-shaped flowers that are nc visited by insects. Both bumblebees an hummingbirds are generally not as inter ested in the shallow, open flowers fre quented by less specialized visitors, prob ably because these flowers provide les nectar and pollen.

Butterflies are conspicuous and beauti ful as they flutter through the meadows but their high profile is misleading. Not a abundant as the flies, in terms of bot number of species and individuals, butter flies visit a relatively small subset of th wildflowers in the area. Moths, too, appea to be significant pollinators for only a fev species of plants.

For many wildflowers in the Colorad Rockies, then, flies outshadow bees, but terflies, and hummingbirds as flying geni talia. Without these insects, which mos people find slightly repulsive, many of th wildflowers that make visiting an alpin meadow so delightful would fail to se seed. So, before brushing a fly off a flowe in preparation for taking the perfect photo graph, we should pause in appreciation o its work—and perhaps even make it th focus of the picture. □



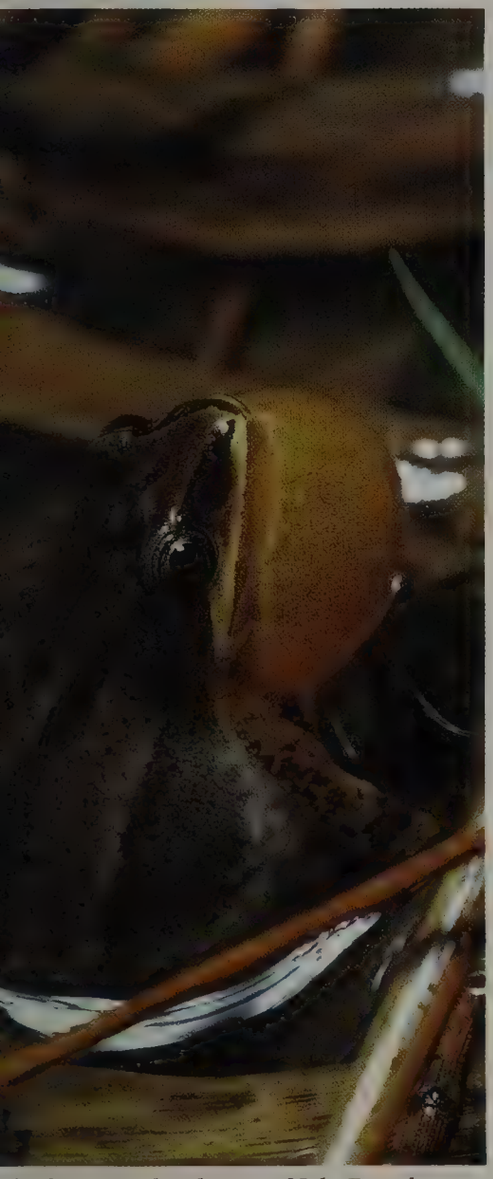


oseph and Arlene Johannets; Fototracs

Between the Devil and the Deep Blue Lake

During breeding season, Isle Royale's chorus frogs have to make some tough choices

by Josh Van Buskirk and David C. Smith



The bare, rocky shores of Isle Royale, on Lake Superior, contain many small pools where chorus frogs lay their eggs. A male, inset, inflates his vocal sac to call for a mate; often, she ignores his choice of site and leads him to another breeding pool.

Robert P. Carr; Bruce Coleman, Inc.

Each year toward the end of the long winter in northern Michigan, when most people are looking forward to warm weather and sunshine, we eagerly await the arrival of heavy rains and damp, foggy nights. For us, the spring rains signal the beginning of another breeding season for chorus frogs. Throughout their wide range, which includes much of eastern North America, these inch-long, brownish green amphibians awake from hibernation on wet evenings in early spring to begin their mating activities. Within weeks of emerging, they must make the most important choice of their short lives—where to lay their eggs. A wrong move could mean that all their offspring will be lost to a predator or perish in a shallow, evaporating pool.

On the shores of northwestern Lake Superior, at Isle Royale National Park, the frogs face an especially difficult challenge. Recurrent northeastern storms pound the small islands and peninsulas with waves and ice, washing the bedrock free of soil and young trees. Hundreds of washtub-size splash pools speckle the rocky shorelines, and these become the breeding pools for chorus frogs. Because they are free of aquatic vegetation or accumulated detritus, splash pools allow us clear observations of the frogs and tadpoles that live in them. We have been studying these frogs at Isle Royale since 1979.

Chorus frog adults spend the summer and fall in the dense spruce and fir forests above the shore, foraging for insects and worms in the litter beneath the trees. As cold weather approaches, they bury themselves beneath a few inches of soil, where they overwinter. Although their body temperatures fall below freezing, a natural chemical "antifreeze" in the frogs' blood, together with enhanced levels of blood sugar, allows them to survive temperatures as low as 22° F by controlling the formation of ice crystals. Soon after thawing out in spring, the males travel to the edges of little pools on the exposed shores, where they spend several weeks calling to attract mates. Females usually stay only two or three nights at the shore, during which time they choose both a mate and the pool in which they will deposit their eggs.

When she is ready to extrude eggs, a female frog approaches a calling male and initiates a position known as amplexus: the male rides the female's back, hooking his "thumbs" around her forelegs. As she releases several jellylike clusters—each containing between ten and seventy eggs—onto the pool's rocky bottom, the male blankets them with sperm. While the male chooses the pool from which he will call, the female decides where the eggs will be laid because the amplexing pair travels from pool to pool under her power.

Not all the rock pools are suitable nurseries. Those that are too close to the lake will be scoured out by storm waves before the tadpoles have had sufficient time to mature. Since they require eight to twelve weeks to develop from egg to froglet, tadpoles that live in the lower pools frequently lose the race to metamorphose before a summer storm washes them out. We found that roughly 15 percent of all tadpoles are carried into the lake by waves before they can turn into frogs. Tadpoles washed into Lake Superior soon perish,



A male clings tightly to his mate as she travels to several breeding pools.
James C. Godwin

for the lake contains many predatory fish, and its rough waters prevent the growth of periphyton—the algal and microbial slime on rock that is the tadpole's main food.

Some pools are too shallow to allow chorus frog tadpoles to survive and may dry up during a midsummer drought—just before most tadpoles acquire the ability to breathe air. Tadpoles extract oxygen from the water through gills located near the back of the mouth, and their permeable skin is highly vulnerable to water loss. Most chorus frogs lay their eggs in pools that are more than four inches deep, which seems to be the minimum depth sufficient to last through their offsprings' development. Even so, we have found that about 10 percent of tadpole populations die each year in small pools that are shallow enough to dry out.

Larger pools at the edge of the forest may seem ideal for tadpoles because of their size and distance from the lake, yet we noticed that the breeding frogs avoided them. The reason was not hard to find. These pools are favored by a large dragonfly, *Aeshna juncea,* whose larvae live there year round for three years while they mature into air-breathing adults. Dragonfly larvae prey upon tadpoles and will even eat the embryos as soon as they begin to wriggle within their jellylike egg masses.

In one of our earliest experiments, we found that removing the dragonfly larvae permitted tadpoles to survive in the upper pools, but that adding dragonflies into lower pools quickly wiped tadpoles out. And when we transplanted tadpoles into pools that already contained dragonflies, we found that both their behavior and physiology changed to help them coexist with the predators. These tadpoles spent less time swimming and feeding, which made them less conspicuous but also slowed their growth. They also developed more muscular tail fins, which improved their swimming speed. These responses, however, still could not make the upper pools a secure place for young chorus frogs. Fewer than 5 percent of the tadpoles that were transplanted to upper pools survived, a percentage that agrees with our estimates of natural survival rates there.

For optimal survival of their offspring, then, female frogs must select pools in a middle zone, just below where the dragonflies live and just above the region washed by the waves of summer storms. In fact, frogs do lay most of their eggs in the middle zone. But we wanted to know if that was because females actively determine whether a pool contains dragonflies before they lead males there or if they simply travel a fixed distance toward shore from the forest, skipping the region where dragonflies live. To find out, we introduced dragonfly larvae to lower-zone pools and then counted the number of eggs chorus frogs laid in them. When we compared the numbers with those of eggs laid in nearby pools having no dragonflies, the answer was clear: egg-laying frogs avoided the hazardous pools, even when two pools were almost side by side.

Although free of dragonflies, pools in the intermediate zone present another hazard to growing tadpoles—competition among them for food. In this zone, the density of tadpoles can become extremely high, and we have repeatedly observed that pools overcrowded with hatchlings produce very few froglets. Those that d manage to reach adulthood in crowde pools are weak and stunted, while the les crowded pools produce large and health froglets. When we added supplementa food (Purina rabbit chow) to a series o crowded pools, the emerging frogs prove to be healthy and robust. Small, under nourished froglets coming out of crowde pools take at least a year longer than large froglets to reach maturity, and their chanc of reproducing is therefore reduced. (Th survival rate of chorus frogs from one yea to the next is usually less than 15 percen under the best of conditions.)

Females that arrive in the midzone dur ing the latter part of the breeding seaso are confronted with pools already occu pied by larger tadpoles. Through furthe experiments we established, with som margin for error, that females lay mor eggs in pools that are relatively free o other tadpoles. However, the frogs' judg ment of crowding is far from perfect. Ide ally, all females should leave their clump of eggs in the least crowded of the mid zone pools, so that all the eggs would ten to become evenly distributed among th

A dragonfly larva of the genus Aeshna, *below, is related to those that prey on chorus frog tadpoles. Developing frog embryos, inset, are beginning to show tai buds. Just before hopping about on land, a froglet, right, is especially vulnerable, as it can no longer swim rapidly.*
Keith Kent; Peter Arnold, Inc.



J. Va

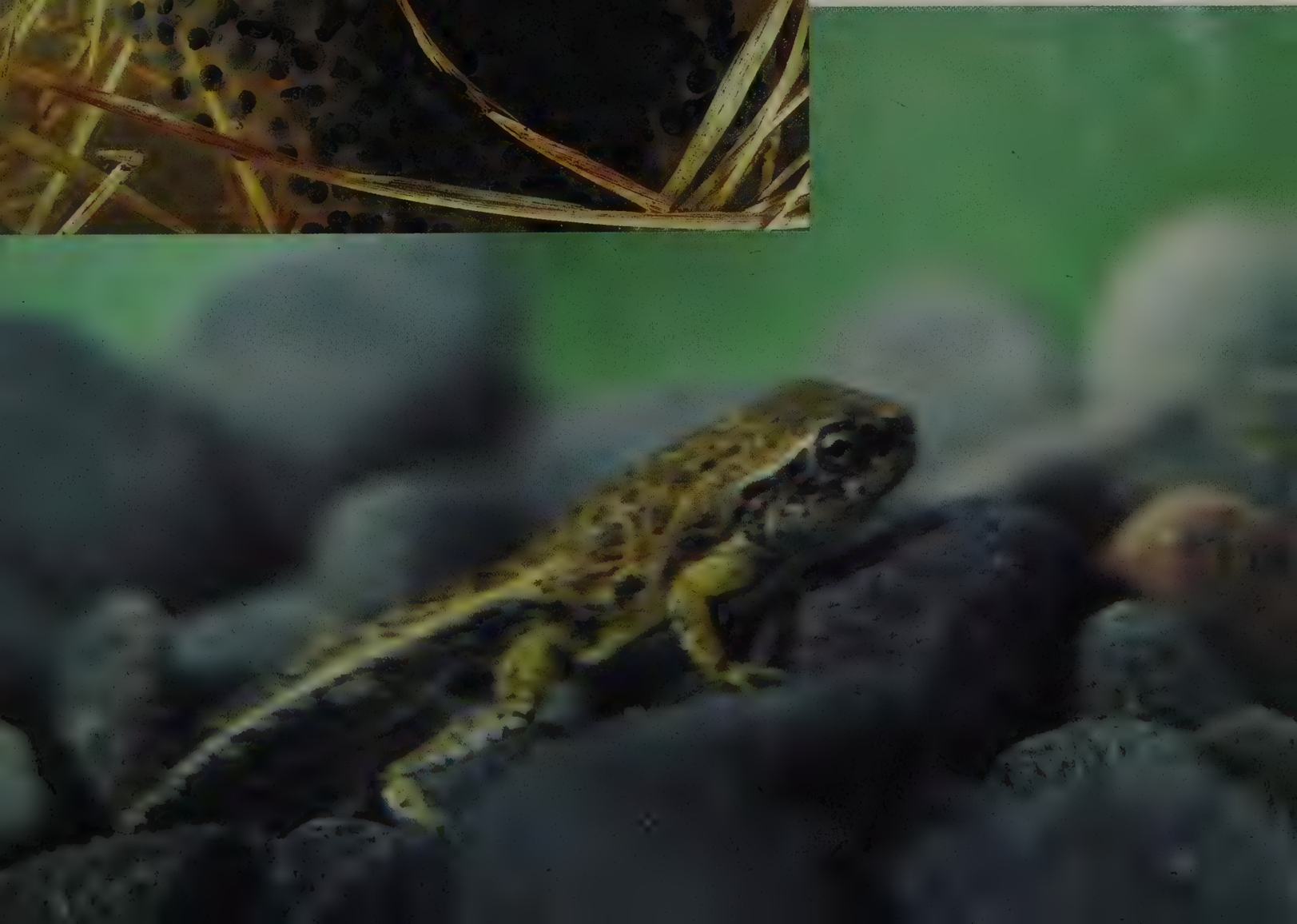
ools. But, in fact, tadpole density varies idely in the shore pools. Many frogs lay eir eggs in pools already so crowded ith tadpoles that there is virtually no hance of success for late arrivals.

Thus, the dual threats of the waves of ake Superior and dragonfly predation not nly restrict the tadpoles to a narrow range f habitats on the exposed rocky shore but lso have the important indirect effect of mposing a cap on chorus frog numbers. ecause female frogs are forced to choose mong relatively few pools, crowding and ood competition become the predominant eatures of tadpole life and regulate popuation size.

We believe that the process of habitat election for the chorus frogs at Isle Royale may be a useful model for understanding the breeding ecology of many species of frogs. Most breed in ponds that fall somewhere on the continuum between large permanent lakes and ephemeral puddles. A major drawback for frogs using permanent ponds is that they also provide a hospitable environment for predacious fish, salamanders, and insect larvae. Temporary pools, on the other hand, cannot support predators for long, but may also dry up so rapidly that tadpoles cannot complete development in them. Thus, in choosing where to lay their eggs, frogs probably are sensitive to water depth, proximity to the lakeshore, and the presence of predators and other tadpoles. How they sense and weigh these factors is still not known. Some amphibians avoid water containing chemicals from predatory fish; a similar mechanism may help breeding chorus frogs stay clear of pools that contain dragonfly larvae.

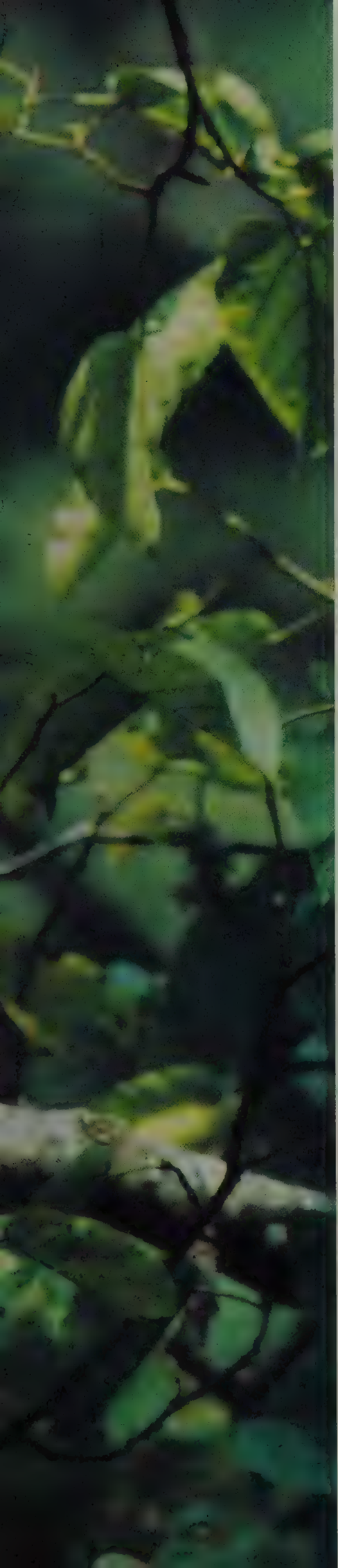
On a damp and foggy May evening, when the conditions are just right for amphibian breeding, Isle Royale's shores teem with frogs awaiting their opportunity. Males inflate their balloonlike vocal sacs, then fill the air with incessant *brrreet* courtship songs, while females climb from pool to pool in search of the right mate. Mated pairs swim along the bottoms of pools depositing eggs and sperm in the water, while first-year frogs hop about but do not participate in breeding. How can these frogs decide where to leave their eggs in the midst of such bedlam? What cues are they using to judge the susceptibility of a pool to desiccation or wavewash, to decide if other frogs have already filled the pool to capacity with eggs, or to determine whether a dragonfly lurks in some corner? While we may not understand how they do it, we know that their system works well. Indeed, if we were in charge of distributing these eggs for the good of the tadpoles, could we do better than the frogs? In spite of all our accumulated information on the Isle Royale pools, we don't think so. □







Lysa Leland



Although abundant in the Kibale Forest, the red colobus, left, is rarely seen elsewhere in Uganda, largely because of the loss of forest habitat. Below: A crowned eagle soars above the forest.

Ulrich Ristig



Teamwork Tactics

Kibale Forest's monkeys and eagles each depend on strategic cooperation for survival

by Lysa Leland and Thomas T. Struhsaker

A group of mangabey monkeys grunted softly to one another while foraging in the thick foliage overhead. Suddenly the forest erupted in a burst of whoop-gobbles, chitters, and staccato-grunts as mangabeys rained to the ground. Just as the last two—both adult males—dropped down, an enormous, dark, menacing form plummeted silently from the sky. With wings outstretched nearly six feet, it swooped startlingly close overhead and deftly negotiated its way through the understory maze. Another dark shadow followed the first. For a brief moment we felt as though the age of pterodactyls had returned. But what had just occurred was an attack by African crowned eagles (*Spizaetus coronatus,* formerly known as *Stephanoaetus coronatus*).

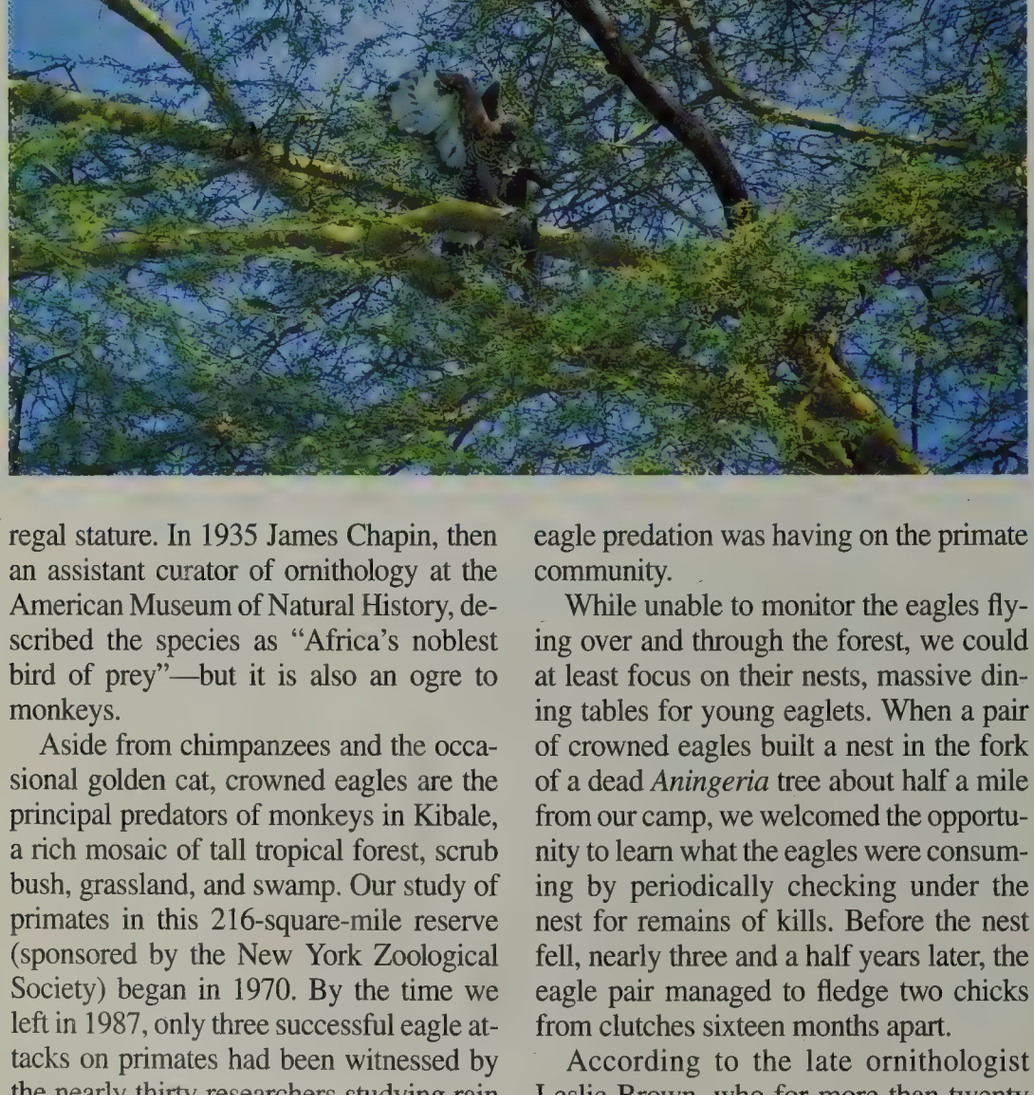
In the Kibale Forest Reserve of western Uganda, attacks by crowned eagles are not often observed, and in most cases the eagles fly off with empty talons. For us, a failed attack was always a relief. Field research had drawn us into the intimate lives of monkeys, and as a fellow primates we identified more closely with them. Yet we could not help being awed by the magnificent birds, considered the royalty of African raptors because of their immense power and strength. A conspicuous feathered crest adds to the crowned eagle's

Peter Steyn



A crowned eagle, below, will kill prey many times its own weight. Unable to carry the whole carcass back to the nest, the bird dismembers it and caches the pieces in a nearby tree. Right: A crowned eagle sits in its nest. Constructed of dry sticks and pieces of lianas, nests are at least six feet across.

Ulrich Ristig



regal stature. In 1935 James Chapin, then an assistant curator of ornithology at the American Museum of Natural History, described the species as "Africa's noblest bird of prey"—but it is also an ogre to monkeys.

Aside from chimpanzees and the occasional golden cat, crowned eagles are the principal predators of monkeys in Kibale, a rich mosaic of tall tropical forest, scrub bush, grassland, and swamp. Our study of primates in this 216-square-mile reserve (sponsored by the New York Zoological Society) began in 1970. By the time we left in 1987, only three successful eagle attacks on primates had been witnessed by the nearly thirty researchers studying rain forest ecology.

Nonetheless, crowned eagles are a pervasive presence in the forest. Their dramatic and vocal aerial displays hundreds of feet above the canopy, their silent reconnaissance flights over the forest, their attacks on monkeys, and the uproar of bird and monkey alarm calls following these attacks argue that not all their hunts are in vain. Our extensive research on monkeys in Kibale gave us the unique opportunity to look at this eagle from a primate's perspective and to learn what impact crowned eagle predation was having on the primate community.

While unable to monitor the eagles flying over and through the forest, we could at least focus on their nests, massive dining tables for young eaglets. When a pair of crowned eagles built a nest in the fork of a dead *Aningeria* tree about half a mile from our camp, we welcomed the opportunity to learn what the eagles were consuming by periodically checking under the nest for remains of kills. Before the nest fell, nearly three and a half years later, the eagle pair managed to fledge two chicks from clutches sixteen months apart.

According to the late ornithologist Leslie Brown, who for more than twenty years studied crowned eagles near his home in Kenya, the burden of hunting falls mostly on the male, even during courtship and nest building. During incubation, he brings food on the average of every three days for his mate. For several weeks after the chick hatches, the male nearly doubles his efforts until his mate is able to leave the chick unattended.

Although crowned eagles weigh only seven to nine pounds—the weight of a newborn child—they are extremely powerful for their size and will not hesitate to attack mammals, including humans, many times their own weight. Known in some parts of Africa as "leopards of the air," these eagles regularly kill adult monkeys and forest antelopes weighing twenty-five pounds and have been known to kill bushbucks weighing more than forty pounds. In South Africa, a crowned eagle critically wounded a forty-four-pound child before a bystander intervened and killed the eagle with a garden hoe. Leslie Brown himself was once attacked by an eagle and described the sensation as resembling "a blow with [a] heavy stick." Perhaps he got off lightly.

According to Brown, crowned eagle



kill by swooping down at great speed and stunning their prey with a powerful blow. In Kibale, however, dissections we made of three freshly killed monkeys revealed talon wounds inflicted with extraordinary precision to the heart. In one juvenile red colobus, we found the heart was pierced in three different places—by one talon. It apparently went through one side, came out the other, and curled back to penetrate the heart once again before withdrawing.

An eagle can kill a monkey several times its own weight, but carrying it off is a different matter. From time to time, we came upon an eagle feeding on a dead monkey, presumably after a successful attack. We observed that the predator first plucks off the hair and then discards the guts and dismembers the carcass. To prevent bush pigs, civets, driver ants, or other scavengers from stealing the meat, eagles have been known to cache kills in the branches of trees.

We suspect that eagles bring fillets from the caches to their young and that this may account for the scarcity of discarded bones under the nest near our camp. We found only 108 bones there in just under two years. (Others may have been dragged off by scavengers.) From these bones, Meave Leakey, of the National Museums of Kenya, identified twenty-nine monkeys and eight other vertebrates. During our time in Kibale, we and other researchers collected another twelve monkeys we believed were killed by crowned eagles (from direct or indirect evidence). Out of a total of forty-nine eagle kills, forty-one were monkeys and the rest were forest antelopes (two species of duiker), a palm civet, and a black-and-white casqued hornbill.

That the great majority of these kills were primates is not surprising. The density of monkeys in Kibale is the highest of any tropical forest: more than 1,400 individuals per square mile. If we assume a home range for an eagle pair and its young

A red colobus weighs about twenty-two pounds and is four feet tall when its legs are fully extended, below. It is able to leap great distances because of its very long hind foot—the equivalent of a shoe size of 18. Right: An infant black-and-white colobus clings to its mother.

Lysa Leland



of 3.8 square miles (based on Leslie Brown's estimates for crowned eagles of the Aberdare Mountain Forest in Kenya), this represents nearly 1,800 monkeys per eagle, a rough estimate but nevertheless eight times the maximum prey noted by wildlife biologist George Schaller for large felids in the African savanna. Extrapolating from Brown's calculation of fourteen ounces of prey per eagle per day (including wastage), a pair of eagles with young would have to kill about 100 to 120 medium-sized monkeys annually—only about 2 percent of the primates in their range. By comparison, Schaller estimated that large predators in Tanzania's Serengeti National Park take up to 10 percent of the available prey.

Although Kibale is home to eleven species of primates, we found the remains of only six under the nest; not included were the largest species (baboons and chimpanzees) and the smallest (nocturnal bushbabies and pottos). With one exception, crowned eagles took prey in relation to abundance.

Of the thirty-four identified monkey kills, ten were red colobus, the most numerous species in Kibale, and eight were redtail guenons, the next most populous. Five were black-and-white colobus, and four, blue guenons—both of which are found in about the same numbers—and one was a lhoesti, a rarely seen ground-dwelling species for which we have no reliable estimates. The six remaining kills were all mangabeys. Although mangabeys are the least numerous monkey in Kibale, they are the third most common prey of eagles. Two years earlier, wildlife biologist Joe Skorupa obtained similar results from another nest in Kibale in a different part of the forest.

Given their low numbers, many more black-and-white colobus and mangabeys were killed than one would expect. What surprised us even more, however, was that eagles took proportionately far fewer red colobus than we would expect. Why were eagles selecting certain monkeys over others? We found no single or obvious answer. Black-and-white colobus, by virtue of their striking coat pattern, stand out like dart boards when feeding atop trees, but the dark, well-camouflaged mangabeys are equally vulnerable to attack. Both species frequently forage in swamps where trees are short and cover minimal and the risk of attack may be greater.

Perhaps the most critical factor is group size. Mangabeys and black-and-white colobus live in the two smallest primate social groups, averaging fifteen and eight individuals, respectively. We might expect that monkeys living in small groups would have a reduced likelihood of being noticed by predators. However, those species living in large groups seem to have an advantage for several reasons. The odds of being targeted during an attack decrease with more individuals around; more eyes increase the chances of spotting potential predators; and greater numbers can confuse and distract the predator. Red colobus monkeys, Kibale's most abundant and vocal species, live in groups of up to eighty individuals and are least vulnerable to eagles attacks. They also have the advantage of congregating with alert redtails, which rank second to red colobus both in group size and in being less vulnerable to attack. By associating with one another, these monkeys may be reducing the risk of eagle predation.

We made another unexpected discovery. In analyzing prey by age and sex, we found that eagles took a greater number of adult and subadult males in all species but one. The red colobus male was the exception, and again, black-and-white colobus and mangabey males were the primary targets. Why males? And why not red colobus males? Could this explain the greater proportion of adult females found in social groups?

Surprise appears to be a critical ingredient for the success of eagle attacks. In a forest filled with vigilant prey, however such a prominent predator cannot remain undetected for long. When threatened black-and-white casqued hornbills and great blue turacos deafen the forest with their raucous, squawking alarms. Monkeys react to this wild din with a chain of alarms erupting across the forest: pops and pyows, belching roars, pant-grunts, and whoop-gobbles—an effective early warning system allowing prey to track eagle movements.

To avoid detection, crowned eagles may have developed an effective counter strategy based on the defensive behavior of adult males. Adult and subadult male





The crowned eagle's crest is most prominent when the animal is alert.
Lorna Stanton; Anthony Bannister Photo Library

monkeys, unlike females and young, are less likely to hide and more likely to demonstrate openly against eagles. If a crowned eagle is perched nearby in a tree, male monkeys will often react by vocalizing, leaping up and down on branches, or chasing it off. On one occasion we saw two males—one redtail and one blue guenon—rush toward a liana thicket in which an eagle had made a successful attack. As they approached the thicket, the blue monkey suddenly stopped and turned away, presumably after discovering that the victim was not from his group. The redtail male plunged into the thicket, flushing out the eagle, which flew off with a juvenile redtail in its talons.

Eagles may use such male temerity to their advantage, especially when a female and male eagle hunt together. Cooperative hunting has been witnessed on several occasions in Kibale and elsewhere. The first eagle can distract a group of monkeys either by soaring through their midst or perching nearby. While female monkeys and their young leap to greater safety behind thick foliage, the attention of male monkeys is absorbed in vocal and threatening displays against this intruder. The second eagle, following a few moments behind its mate, swoops in on its preoccupied target. Such tactics may well account for higher male mortality in species other than red colobus.

Red colobus may benefit from living in large groups and associating with other species, but this doesn't explain why their males can't be taken by surprise as well. Although similar in size to black-and-white colobus and mangabey males, Kibale's red colobus males are considered the most aggressive primate in the forest. These agile monkeys—known for their kamikazelike leaps—will sometimes chase male chimpanzees, their potential predators, who may weigh more than four times as much, down from the tree canopy and along the ground. In a logged-over part of the forest, Joe Skorupa was physically attacked by a phalanx of four red colobus males. Local villagers claim that red colobus attack farmers, usually on land recently cleared of forest. No other Kibale primate has been known to challenge either chimpanzees or humans in this way. In fearlessness, crowned eagles may have met their match.

When it comes to teamwork, red colobus males have another advantage over other monkeys. Their social organization is unusual, exhibited by only a few species of primate—and by only a handful of mammal societies in general (*see* "Leopard Killers of Mahale," *Natural History*, March 1988). In most group-living species, including black-and-white colobus and mangabeys, related females form the stable core of the group; males are usually transient and peripheral, and if two or more are in the group, they are unrelated to one another. Extra-group males live solitarily and therefore may be more vulnerable to eagle attack. Red colobus males, however, form the nucleus of the group. They are closely related and more likely to react as a strong defensive cadre in the face of outside aggression.

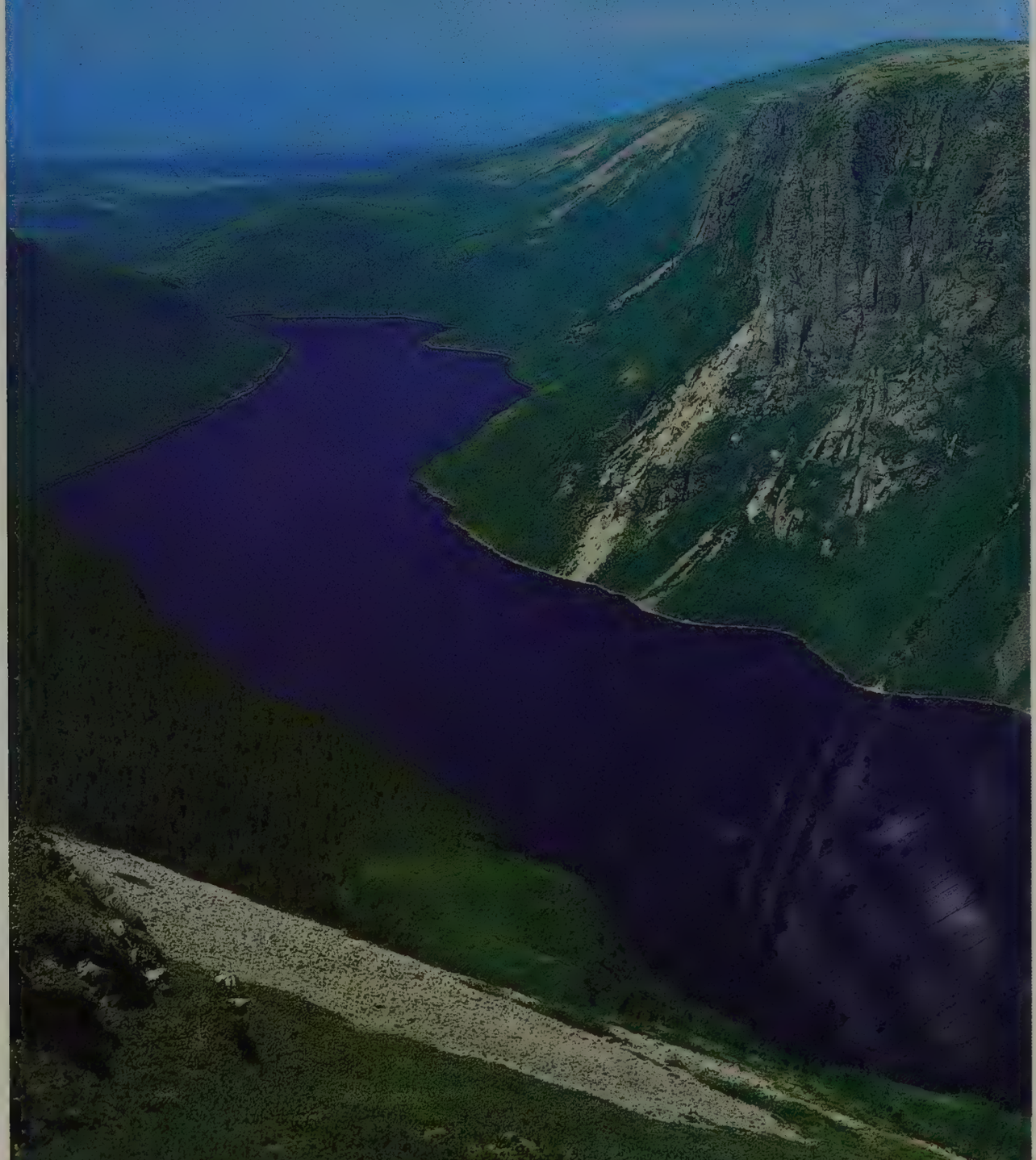
On one occasion, the tight teamwork of red colobus males was particularly striking in the presence of a pair of eagles. While females and young remained hidden in foliage, three adult males, side by side, jumped up and down, shaking foliage on an exposed limb, screaming and quavering at a pair of crowned eagles that had perched nearby. Although the eagles made several passes at these colobus, the males did not budge from their position. The combination of this monkey's strongly aggressive nature and its cohesive cooperation in defense may present a risk crowned eagles would rather not take.

The risk involved in hunting monkey may even affect the breeding strategy o crowned eagles. Although the age a which eaglets leave the nest is similar fo crowned eagles in various habitats, th postfledging period, when the young eagl still depends on its parents for food, ca vary greatly. By comparing the diet an breeding rhythms of crowned eagles i seven different study areas, Joe Skorup found that eagles on a diet of larger ani mals, such as primates or antelopes, had postfledging period nearly twice as long a that of eagles hunting smaller prey. He be lieves that the protracted parental care i Kibale's eagles is due not to the sparsity o large prey, as in some areas, but to the dif ficulty and risk involved in attackin Kibale's monkeys.

He calls this "the formidable prey hy pothesis." To outmaneuver their prey, ea gles must distinguish the idiosyncrasie and defense tactics of each primat species. The greater risks associated wit eaglets' learning to hunt aggressive, a well as brainier, primates may account fo the very long parental tolerance of juvenil dependence by Kibale's crowned eagles— 300 days or more—one of the longes postfledging dependency periods recorde for any bird species.

Eagles and primates in Kibale are en meshed in a battle for survival. In habitat where prey, such as hyrax, are small an easy to kill, crowned eagles tend to bree annually. But in Kibale they may have t delay breeding until their offspring ca learn to hunt primates successfully. Som primates may lose a disproportionat number of individuals to predation. Male in particular seem to be at greater risk be cause they try to protect females an young, because they lack the protection o large groups, or because they lack clos teamwork. In trying to avoid risk and max imize survival, eagles and primates hav had to modify their behavior in relation t one another. Only red colobus seem to b ahead of the game. □

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Atlantic Canada

IMAGINE, if you will, a land of towering fiords and icebergs or warm sand dunes along an endless stretch of seashore. Picture a golden lake shimmering between two seas or a windswept isle carpeted with thousands of puffins. Visualize a charming city of Queen ☛

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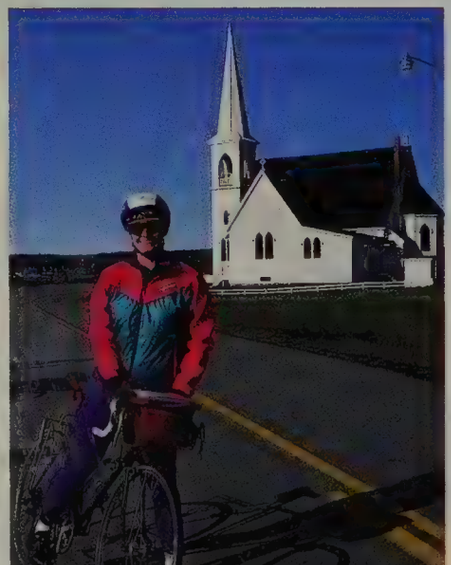


Prince Edward Island is renowned for its miles of unspoiled beaches.

Both summer and fall are excellent times to tour Atlantic Canada by bicycle.

On the cover: Gros Morne's Ten Mile Pond, Newfoundland.

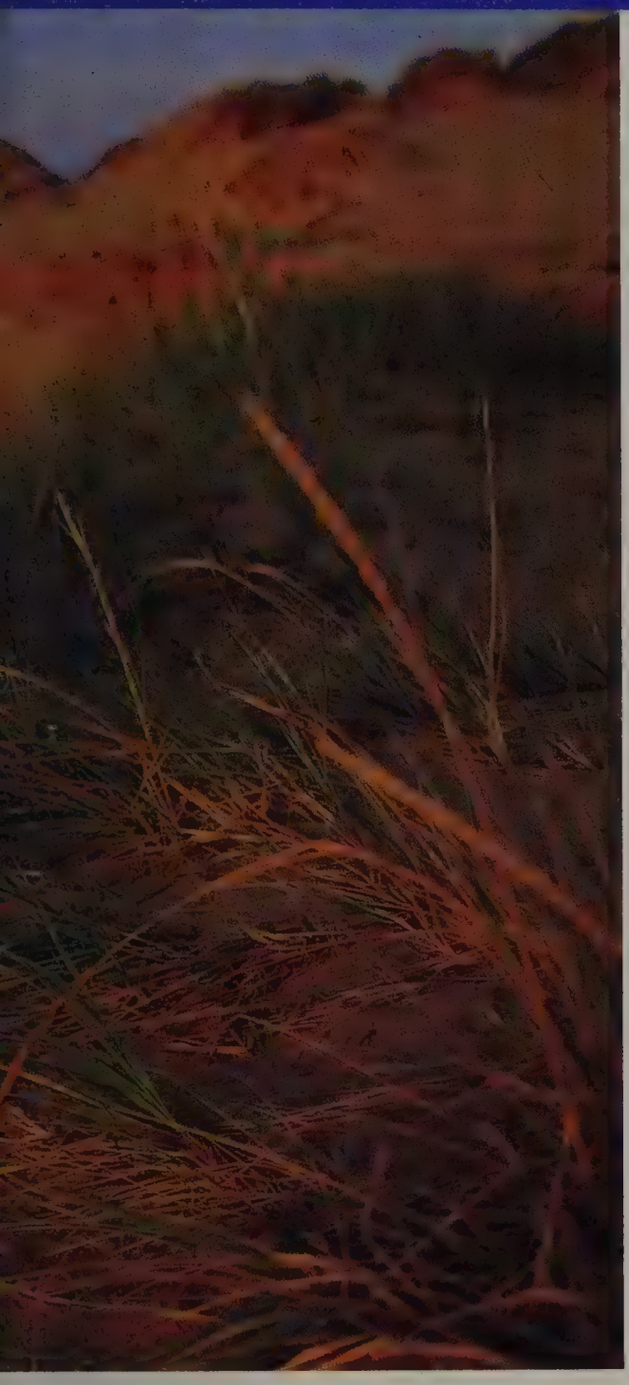
Anne-style houses and cobbled streets or a bluff in the soft light of evening, topped with a classic red-and-white lighthouse looking out to sea. Picture a herd of caribou grazing the Arctic tundra as far as the eye can see or a humpback whale breaching with a great roar of water.



A wonderful fantasy? Not at all. This is Atlantic Canada: four provinces right next door to each other, but each unique. The province of Newfoundland and Labrador has fiords and towering mountains as breathtaking as any in Norway; Prince Edward Island is fringed by hundreds of miles of sand dunes and beaches; Nova Scotia's Bras D'Or Lake has been called the world's most beautiful lake; and some of the largest bird colonies on the Eastern Seaboard are found here. Halifax, Nova Scotia, with its distinct British flavor, is one of the loveliest cities in North America. And off the coast of New Brunswick, the Bay of Fundy offers some of the best whale-watching in North America. Finally, West Point, Prince Edward Island, has one of the most picturesque lighthouses you will ever see. The four Atlantic provinces of Canada offer more in one area than any other place I can think of in North America. The provinces boast not only charming seaside villages (most with comfortable accommodations

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and fine dining), but they have some of the best wilderness left on the continent.

In the section below, I describe some of my favorite activities in the four provinces. I wish to warn the reader, however, that this is an opinionated and very selective list. By no means does it exhaust the experiences to be found in Atlantic Canada. All the activities listed here are available in package vacations through many excellent tour operators—or you can plan your own trip using the comprehensive guidebooks, maps and nature publications distributed free by the four provinces.

CYCLING

The rolling hills and gentle coastline of Prince Edward Island present a cycling opportunity unlike anything else in North America. Excellent blacktop and red-clay country roads, with little traffic, wander about this lush island, past steep-roofed farmhouses, emerald fields, red-clay bluffs, sand dunes, beaches and estuaries bobbing with boats. The roads are dotted with fishing and farming villages with such names as Victoria-by-the-sea, Cavendish, and French River, most of which offer bed-and-breakfasts, seaside lodges and country inns. This rural province was the setting for *Anne of Green Gables*, and of this island its author, Lucy Maud Montgomery, wrote: "It is the sea which makes Prince Edward Island...it is ever visible somewhere, if only a tiny blue gap between distant hills, or a turquoise gleam through the dark boughs of a spruce....[The island] floats on the waves of the blue gulf, a green seclusion and haunt of ancient peace."

Any cycling tour must include the spectacular bike path through the vast dunescapes of Prince Edward Island National Park and many of the provincial parks that line the shore. Prince Edward Island has some of the most beautiful (and uncrowded) beaches on the Atlantic with waters as warm as those off the Carolina coast. Indeed, Cavendish is Canada's most famous beach.

The abandoned grades of the old P.E.I. railroad are now being turned into a network of biking and hiking trails that will crisscross the island. When completed, this "rails-to-trails" system will be one of the outstanding bike routes in Canada.

New Brunswick is also famous for its cycling. Kouchibouguac National Park, for example, has 18 miles of special bike trails. This is a landscape of barrier islands, marram grass, deserted beaches, lagoons, fresh- and saltwater marshes and 223 species of birds—including 18,000 pairs of terns in several hundred colonies. After working up a sweat, take a swim; the southeast coast of New Brunswick shares the same warm waters and vast sandy beaches as Prince Edward Island. The pastoral Saint John River Valley has fabulous cycling through lush farmland and streams crossed by covered bridges—of which there are more in New Brunswick than in Vermont. Or try a combination mountain bike–ferry trip around the three Fundy Islands: Grand Manan, Campobello, and Deer.



Period architecture and comfortable accommodations are combined in this charming Nova Scotia bed-and-breakfast.

BIRDING

Among ornithologists and serious birders, the Atlantic provinces are already famous. John James Audubon found the bird life in the region to be outstanding, and it is no coincidence

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that an early Roger Tory Peterson book was *The Birds of Newfoundland.* The bird life here is without compare. From the gannet-covered sea stacks of Newfoundland and the huge razorbill colonies of Nova Scotia, to the great blue heron nesting grounds of Prince Edward Island and the extremely rare piping plovers of New Brunswick, this is the place to double your life list.

Take New Brunswick. It lies on the Atlantic flyway, that great highway of migrating birds. Because of the province's varied habitats—from sand dunes to sea cliffs, from boreal forest to mixed woodlands, from mountainous uplands to coastal marshes—New Brunswick is host to nearly 400 species of birds. As a result, birders can observe southerly species such as snowy egrets, tri-colored herons and glossy ibises along with northerly and Arctic birds such as auks, shearwaters, puffins, murres, kittiwakes and jaegers. The fall migration down the flyway, which begins in late July, is an extravaganza of birdlife. One of the best places to observe the migration is at Mary's Point Shepody National Wildlife Area. Here, vast flocks of shorebirds blanket the mud flats at low tide, fattening up for the trip south. To see (and hear) 400,000 birds explode into flight at once is a heart-stopping experience. In August and September, wave after wave of migrations pass through, including the songbird migration. The songbird migration carries with it a number of raptors such as falcons. Have you ever seen a peregrine falcon, diving at close to 70 miles an hour, snatch a bird in midflight? Well then, come to New Brunswick.



Puffins are but one of several hundred bird species found throughout Atlantic Canada. In addition, nearly half of the world's whale species frequent the region's offshore waters. During the fall migration period, boat tours typically yield as many as twelve sightings per trip.

Some of the biggest seabird colonies in the world are found on the Avalon Peninsula of Newfoundland. A driving loop along the coast called the Ring of the Avalon visits most of the big colonies. This tour starts in St. John's and winds along magnificent seacoasts white with thundering surf, lighthouses perched on 1,000-foot bluffs, little fishing villages—and great colonies of seabirds. There is something deeply moving in seeing thousands of birds covering and circling a great sea stack, their mingled cries coming like a great wind across the water. Some colonies are best observed from the road, while others should be visited by boat. Excellent bird cruises are offered at Bay Bulls, 18 miles from St. John's. Three craggy sea stacks are covered with nesting pairs of Leach's storm petrels and puffins, and murres blacken the sky to the horizon.



Whale Watching

Offshore of the four Atlantic provinces the warm Gulf Stream collides and mingles with the frigid Labrador Current, creating waters unsurpassed in sea life and plankton—ideal habitat for whales. Nearly half of the world's whale species can be seen in various parts of these provinces—including humpbacks, pilot whales, minkes, finbacks, sperm whales, great blues and Atlantic right whales. Along some of the coastal drives I have often come across a half dozen cars pulled off the road, everyone watching a group of whales playing and "singing" not a hundred yards from shore. The surer way of meeting whales, however, is on one of the many whale-watching cruises.

The Bay of Fundy is particularly rich in whales during the August-September migration. During this time boat tours usually encounter ten to twelve whales per trip. These whales seem to be curious about the boat; they roll and surface sometimes within yards, looking up and observing the people observing them. Whale-watching tours into the Bay of Fundy depart from several seaside villages in both New Brunswick and Nova Scotia. Many of the cruises also visit bird colonies, and the boats sometimes offer such entertainment as cod-jigging and maritime songs and stories.

The bays along the northeast coast of Newfoundland are also teeming with whales. In Bonavista Bay alone, nearly one fourth of the world's species of whales have been seen. Trinity Bay, one bay over from Bonavista, is the site of an unusual whale-watching tour. Visitors board a research vessel equipped with special computer and sonar equipment that records and plays back the "songs" of the whales. The whales often respond dramatically to these sounds, and a lively "dialogue" between humans and whales ensues.

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Cape St. Mary's on the Avalon Peninsula, Newfoundland, is an ideal place to see large colonies of seabirds.

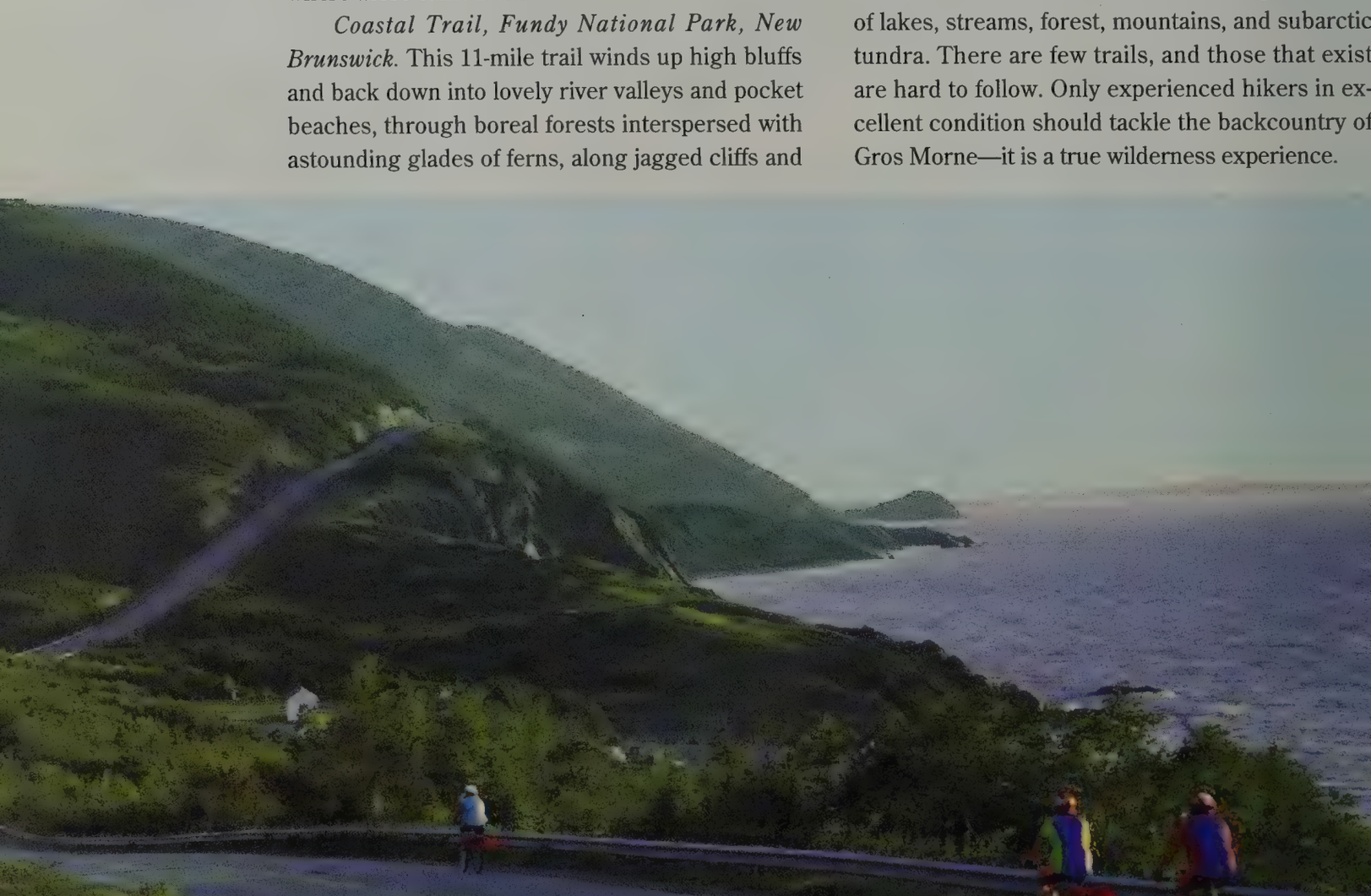
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Hiking

The four provinces offer some of the best hiking anywhere, from pleasant jaunts for the novice to backcountry hiking that would challenge John Muir himself. Again, I offer an idiosyncratic selection; just keep in mind there are a lot more where these came from.

Coastal Trail, Fundy National Park, New Brunswick. This 11-mile trail winds up high bluffs and back down into lovely river valleys and pocket beaches, through boreal forests interspersed with astounding glades of ferns, along jagged cliffs and around pudding-stone rocks sculpted by massive tides. From the cliff tops you will find yourself looking out over the entire upper Bay of Fundy. There are several campsites along the trail. After sunset, while you sit around your campfire, listen to the crying of the seabirds and the surge of the 50-foot tides.

Western Brook Pond into the backcountry of Gros Morne National Park, Newfoundland. Gros Morne has been named a World Heritage Site by the United Nations—joining a short list that includes Yellowstone National Park, the Great Barrier Reef of Australia, and the pyramids of Egypt. The forbidding landscape was created by fire and ice, with landlocked fiords slicing through half-mile-high walls of granite, deep glaciated lakes, volcanic uplifts, 1,000-foot waterfalls and blunt mountains. Perhaps the most awesome gateway to the backcountry of Gros Morne is through Western Brook Pond. Regular boat service takes you to the head of the pond (actually a large ocean inlet now closed off from the sea), where there is a campground. From there a trail winds upward into an immense wilderness of more than 700 square miles of lakes, streams, forest, mountains, and subarctic tundra. There are few trails, and those that exist are hard to follow. Only experienced hikers in excellent condition should tackle the backcountry of Gros Morne—it is a true wilderness experience.



Cycling the Cabot Trail, Cape Breton, Nova Scotia.

I am willing to divulge one well-kept secret to the adventurous. Get out a map of Cape Breton Island, Nova Scotia, and locate the village of Red River near the northern tip. A rough trail, almost unknown, heads north and is the only route along some of the last utterly wild, untamed coastline on the Atlantic. It is an exceedingly difficult trail and should be attempted only by experts.

Walking

There are hundreds, if not thousands, of breathtaking walks in the four provinces. I've found myself exploring small provincial parks, nature preserves, lakes, forests, beaches and islands. I will describe my three favorites.

Skyline Trail, Cape Breton Highlands National Park, Cape Breton Island, Nova Scotia. This

4.3-mile-loop takes you to the edge of the world itself. The trail skirts high bluffs overlooking the sea and winds through a boreal forest of twisted balsam fir and birch. The last time I took this hike I saw several pilot whales playing in the waters below while a bald eagle soared overhead. Moose are also frequently seen on this trail. There are rare Arctic wild flowers as well, set like clusters of jewels in the ground.

Cedar Dunes Provincial Park, West Point, Prince Edward Island. Nowhere is the island feeling of tranquility more powerful than at Cedar Dunes. This seaside trail takes you into an ecologically unique cedar forest. Here, the cedars invaded an area of parallel dunes; the Scottish settlers called the hollows between the ancient dunes "Fairy Walks," because they were mysteriously free of vegetation. The park is graced by the historic West Point Lighthouse, now a charming inn as well as a working lighthouse. At night you can see many blinking lighthouses of New Brunswick across the Northumberland Strait.

Philips Garden Trail, Port au Choix, Newfoundland. This is one of the most beautiful walks in all of North America. The feeling engendered by this isolated point of land, with its lonely lighthouse, sculpted rocks, clumps of scraggly tuckamore and vast, sun-dappled ocean, is beyond description. The walk starts at the small (and superb) archaeological museum at Port au Choix and goes out to the Point Riche lighthouse. If along the way you run into a crew of archaeologists digging in a field, stop by for a chat—Port au Choix has an 8,000-year history of human occupation.

CAMPING

There are outstanding campsites and facilities in all four provinces. In Nova Scotia, the camping is as varied and splendid as the province. You can plan your trip on the map, figure out where you're going to camp, and then make reservations for all your campsites with one quick toll-free call.

Nova Scotia has taken some of the lovely back roads of the province and made them into half a dozen "trails," from the Evangeline Trail and Lighthouse Trail in the south to the spectacular Cabot Trail of Cape Breton Island. These are leisurely car routes (not main highways) that carry the visitor through the scenic coastal areas, rich valleys, villages and parks of Nova Scotia. Along all these trails are dozens of excellent camping areas, most offering amenities such as power and water hookups, showers, restaurants, swimming, boating, hiking and even such activities as horseback riding, charter fishing, canoeing and golf.

Those interested in more solitude will find beautiful camping areas (many reachable only by canoe or kayak) in the huge Kejimkujik National Park, buried deep in the Nova Scotia interior—a land of lakes, ancient hemlock groves and teeming wildlife. The canoeing here often follows historic Micmac Indian routes and portages that follow a web of placid rivers, trails and lakes. The Cabot Trail circling Cape Breton Highlands National Park has magnificent camping (backcountry and roadside as well), with dozens of branching hikes and walks.

Prince Edward Island is another place where camping is beautiful and plentiful. The island is only 140 miles long, and thus from base camp you can explore literally half the island (and then move on to the other half). Of the island's 29 parks, 13 have campgrounds, and there are many private camping areas as well. Most of the park campsites have excellent amenities and are beautifully maintained, and they offer gorgeous views of the sea, bays, lush meadows and fields. The island remains quiet and unspoiled with farmland cultivated right down to the edge of the sea. It retains a strong flavor of a nineteenth-century pastoral paradise—the perfect setting for a camping vacation.





A warm fire is always welcome, whether you are camping in one of Atlantic Canada's well-equipped campsites, or relaxing in the cozy comfort of one of the region's many inns.

TRAVEL TIPS

Atlantic Canada is a day's drive from Boston, Massachusetts, either along Interstate 95 or Coastal Route 1—or through the many efficient car ferries that connect Maine to Nova Scotia as well as the other provinces. The last time I visited the Atlantic provinces, I drove to the ferry terminal in Portland, Maine, and actually ended up (in the comfort of my own car) at the end of the last paved road in Red Bay, Labrador. The provinces all have major airports as well. The roads are even better there than in the U.S., exchange rates are favorable and you won't suffer jet lag (unless you're travelling from Hawaii). The Canadians are as efficient as the Swiss, you won't lose your money in the pay phones, the beer is great and the seafood is, quite

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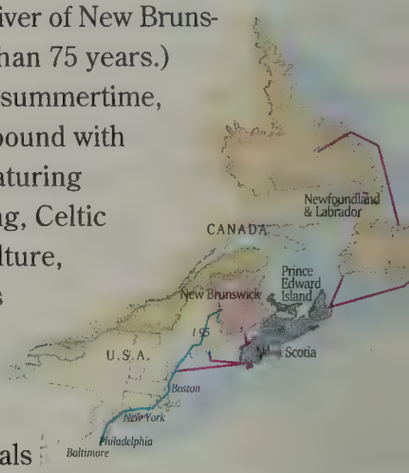
simply, the best. The people are so friendly that if you need to ask directions you'd better figure on being invited to dinner.

Atlantic Canada's cities are charming, and many have the flavor and sophistication of Europe. They provide lively nightlife, excellent hotels, and historic districts with a variety of shopping opportunities. Seaside Saint John, New Brunswick, with its sophisticated boutiques, grand hotels, old marketplaces, pubs and skyscrapers, is a delightful place to spend a few days, whereas Fredericton, New Brunswick ("The City of Stately Elms"), is a wonderful city to stroll about. Halifax, also by the sea, is a city of Victorian and Queen Anne architecture as well as a charming restored waterfront of crooked cobbled streets, old brick buildings, shops, pubs and restaurants. St. John's, Newfoundland is one of my favorite cities, with an exotic atmosphere all its own. And historic Charlottetown, Prince Edward Island, is the birthplace of Canada—in addition to being a distinctive city of dignified homes, steepled churches and historic buildings.



Two completely different environments are found on the same spectacular trail at New Brunswick's Fundy National Park. While hikers admire the interior boreal forests, the famed Hopewell Rocks, sculpted by some of the highest tides in the world, stand nearby.

The villages and towns offer a great number and variety of country inns, bed-and-breakfasts, hotels and cottages. Reservations are always recommended, but are not absolutely necessary. The accommodations are so numerous that I have simply stopped on impulse at a cozy inn or quiet B & B along the way. The provinces boast top resorts and grand nineteenth-century hotels as well as old-fashioned sporting lodges. (My family has been frequenting a wonderful old fishing lodge on the Miramichi River of New Brunswick for more than 75 years.)



During the summertime, the provinces abound with folk festivals featuring bonfires, dancing, Celtic and Acadian culture, crafts, delicious foods and local beer. So far I have run into these festivals in my travels by accident, but someday I'm going to plan a special festival tour.

Vacation packages are available for all the provinces and all the activities mentioned here birding, whale-watching, hiking, camping or cycling (or kayaking, canoeing, hunting, fishing or scuba diving, for that matter). Whatever your pleasure, Atlantic Canada has a vacation for you.

Doug Preston is a freelance journalist and writer

For more information on Atlantic Canada, call toll-free 1 (800) 565-2627, operator 47.



Atlantic Canada.
A Coast Of Difference

How Did Humans Get That Way?

by Ian Tattersall

As the most egotistical of species, we *Homo sapiens* are naturally fascinated with ourselves and our past. In these post-Darwinian days, the ancient question, "What is Man?" has largely been replaced by another: "How did we get to be the way we are?" This Darwinian perspective has unfortunately led to a widespread feeling that becoming human was a stately process that gradually unfolded during the five million or more years that separate us from the first bipedal apes. A special noun, *hominization* (particularly beloved of continental Europeans), has even been invented for this process.

The indistinguishable gradation between nonhuman and human implied by this term may explain why recent students of our fossil record have generally avoided broaching the issue of what we mean when we describe ourselves as "human." After all, if we gradually became what we are, why arbitrarily identify any point in this long, steady jour-

A special series of articles in conjunction with the opening April 23 of the Hall of Human Biology and Evolution at the American Museum of Natural History

ney as the moment when our lineage achieved humanity?

One of the implicit themes of the American Museum of Natural History's new Hall of Human Biology and Evolution is that becoming human was not a gradual process: rather, at discrete points revealed in our fossil and archeological records, we acquired the qualities that distinguish us today from all other living species.

In this issue, and in another special section next month, *Natural History* presents articles that bear on this complex subject. Several distinguished authors explore topics ranging from the initial diversification of the higher primates some 40 million years ago (from which the human lineage ultimately emerged) to the incredible outburst of human creativity that accompanied the arrival of the first modern people in Europe more than 30,000 years ago. They also examine the earliest known upright bipeds, the oldest stone tools and the spread of Stone Age technology, the correlation of climate changes with major events in human evolution, and other related topics.

With each of these advances, something happened that set the stage for the emergence of humanity. No one, of course, would argue that the earliest higher primates were in any sense human, but what about the first upright bipeds? Although their mode of locomotion was fundamental to all later developments, most scientists nowadays regard them as "bipedal chimpanzees."

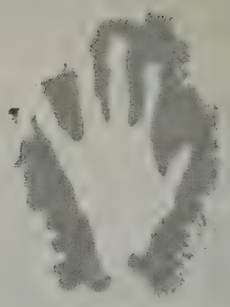
So how about the earliest toolmakers, who came along a million years later? Simple chipping of stone doesn't place them far out of the chimpanzee league and neither does their cranial anatomy. Fancier stone tools, then? They were introduced by humans who looked more like us, particularly below the neck, but apparently the tools brought little significant change in their users' life styles.

Okay, what about the Neanderthals? These large-brained people buried their dead, but only occasionally and without much fuss. And while they made beautifully crafted stone tools, they did so in a unimaginative way. Anatomically modern humans? Well, they were around for a long time before they began to leave evidence in the archeological record of the creativity and inventiveness that we are so proud of in ourselves.

When, then, did "humanity" emerge? Read these articles and judge for yourself. And then, if you're still having trouble with this most intractable of all questions, a visit to the American Museum's new hall may help you to make up your mind.

Ian Tattersall is chairman of the Museum's Department of Anthropology and curator of the Hall of Human Biology and Evolution. He is the author of The Human Odyssey, *which will be published by Prentice Hall this month.*

Egypt's Simian Spring



New fossil finds push back humanity's African roots

by Elwyn Simons

In 1956, while searching through a collection of fossils at the American Museum of Natural History, I came across a small piece of forehead bone, identified as a "possible primate," that had lain neglected for half a century. It had been recovered from the Fayum badlands, sixty miles southwest of Cairo, Egypt, by an amateur collector named Richard Markgraf. The rock in which it was found was known to belong to the geological epoch we call the Oligocene (now estimated to have lasted from 34 to 23 million years ago). Although only the size of a quarter, the fossil displayed two defining characteristics of the Anthropoidea, or higher primates—the large evolutionary group that includes monkeys, apes, and humans. I could tell that the right and left frontal (forehead) bones in this small animal were fused along the midline suture into a single bone, as is the case in all the higher primates. And on the right side, just enough of the rim of the eye socket was preserved for me to establish that it was fully enclosed in the back by bony plates (the eyeballs of more primitive primates are normally encircled by just a thin bar of bone). Neither feature had been previously documented in so old a fossil.

Better late than never, the small piece of bone joined a short list of other fossils discovered in the Fayum between 1906 and 1910 that also appeared to belong to higher primates. The best of the other fossils—both nearly complete mandibles—belonged to two small species named *Parapithecus fraasi* and *Propliopithecus haeckeli.* Both have lower molars with anthropoidean features—in particular, they are broad and flat and have five cusps. In addition, *Propliopithecus* has the same number of the different types of teeth as other Old World anthropoideans, and the two sides of the lower jaw are solidly fused together in the front, another important characteristic of higher primates.

My interest sparked by these tantalizing finds, I began doing fieldwork in the Fayum more than thirty years ago. Since then, my teams and I have succeeded in gathering hundreds of additional primate fossils, documenting the presence of eleven primate species in Oligocene deposits that are 30 to 33 million years old. The largest of these species, a close relative of *Propliopithecus,* is *Aegyptopithecus zeuxis,* a cat-size creature that appears to stand at or near the base of the family tree of the Old World monkeys, apes, and humans. We have collected several skulls and faces of *Aegyptopithecus,* as well as many bones from the rest of its skeleton (*see* "Dawn Ape of the Fayum," *Natural History,* May 1984).

Many of the eleven Oligocene species have anthropoidean



Paleontologists hunt for primate fossils in the Fayum badlands.
David L. Brill

eatures, including the fused frontal bone, enclosed eye socket, ower jaws that are solidly fused together in the front, and the roadened and flattened lower molars with five principal cusps. n certain details, the upper molars also resemble those of more ecent higher primates. Another anthropoidean characteristic is he manner in which the bony ring encircling the eardrum lines he auditory opening at the side of the skull.

The eleven species are diverse in many respects, however. By 985, I had accumulated enough evidence to say that they fell nto several different taxonomic families or subfamilies. Given hat so much diversity had evolved, I had to conclude that the common ancestor of all the higher primates must go back a long way in Africa.

This was only the beginning, however, for in 1983 a Fayum site called Locality 41 had been discovered. Its exposed deposits came from a much deeper layer than those of the quarries we had been mining for fossils. Anthropologist John Kappelman collected samples of Fayum rocks to measure their age. The dating method he used, called paleomagnetic reversal stratigraphy, is based on how the earth reverses its magnetic field at irregular intervals. When a rock forms, it is imprinted with the magnetic alignment of its time. By checking the changing alignments in rocks at numerous successive levels in the Fayum, Kappelman was able to show that the rocks at Locality 41 most likely date to 36 million years ago—in other words, to the late Eocene epoch. The site thus promised to open up a whole earlier chapter in higher primate evolution.



After a primate canine was discovered at Locality 41 in 1984, we shifted our collecting efforts to those deposits and soon were rewarded by the discovery of more primate fossils. From these, in 1989 I was able to describe two new kinds of higher primates. The larger of the two, named *Catopithecus browni,* was documented by several partial lower jaws and one nearly complete skull. As in *Aegyptopithecus,* the eye socket is enclosed, the frontal bones are fused, and the bony ring supporting the eardrum encircles the margin of the ear opening.

For *Catopithecus,* the sequence of teeth in the upper and lower jaws is the same as in the Old World monkeys, apes, and humans. And as in all higher primates, the four upper and four lower incisors are spoon- or chisel-shaped and relatively vertically implanted, with the upper central incisors and lower outer ones being larger than their neighbors. On each side the incisors are followed by a single pair of upper and lower canines, then two pairs of premolars (bicuspids in the parlance of dentists), and lastly three pairs of molars. The premolars and molars resemble those of other early higher primates.

We have recently discovered limb bone fragments from Locality 41 that on the grounds of size also appear to belong to *Catopithecus.* The animal would have been about the size of a modern South American squirrel monkey, with a face of corresponding size, but because its brain was not as big, the head was smaller overall. The second species I named from Locality 41, *Proteopithecus sylviae,* is distinctly smaller and has slightly broader, flatter molars. Tentatively, I have grouped both of these new species in the same family as the later *Aegyptopithecus* and *Propliopithecus.* However, several different families may be involved. Recent (and as yet undescribed) finds of *Proteopithecus* show that it had three pairs of premolars on each side, like New World monkeys and unlike *Aegyptopithecus.*

Last fall I published descriptions of three more animals from Locality 41, each of which appears to represent a different family of higher primates. The first is *Serapia eocaena,* a small creature that resembles species belonging to the later *Parapithecus* and similar genera and should be ranked in the same family. The second, which is still smaller—about the size of a pygmy marmoset—is *Arsinoea kallimos.* The single known jaw has teeth that, in a very general way, look like those of a higher primate. A frontal bone, found about three-quarters of an inch from where the jaw was discovered, exhibits the complete midline fusion found in other higher primates. The third new species, which is the largest of the three, is called *Plesiopithecus taras,* a name meaning "the amazing half-monkey." Although its molars vaguely resemble those of the other Fayum higher primates, it has a greatly enlarged canine or incisor in the lower jaw that is quite unlike the front tooth of any other Fayum primate.

What all of these discoveries add up to is this: as early as 36 million years ago, four or more taxonomic families of higher primates were living in Africa. To derive such diversity from a single ancestral species would have taken a long time—presumably between 5 and 10 million years. Thus higher primates have a considerable, unknown earlier history in Africa.

For nearly a century, paleontologists have been seeking to understand the Eocene roots of the Anthropoidea. Numerous Eocene age primates, belonging to some forty or fifty genera, are known in North America and the combined continent of Europe and Asia. These fall into two broad groups, one resembling the modern tarsiers of Southeast Asia and the other the lorises and Madagascar lemurs. Students of primate history have wanted to derive the earliest African anthropoideans from one or the other—the "tarsioids" or the "lemuroids"—or at least to demonstrate that one has a closer relationship. What now seems most probable is that the higher primates are not derived from either of these northern groups, but arose from a third Eocene ancestral line, very likely in Africa. □

Frost and Found

The melting of an Alpine glacier brings scientists face to face with the Stone Age

by Torstein Sjøvold

Recovering human remains from glaciers is almost routine in the Alps because mountain-climbing casualties occur all too often. In some cases the victims are not readily retrieved, but disappear in a glacier or are covered by snow. Several such bodies turn up nearly every year. From the information given to the police, nothing indicated that this case was to be any different.

Thursday, September 19, 1991, came at the end of a sunny spell in the Ötztal Alps, between Austria and Italy. Erika and Helmut Simon, a German couple who had extended their climbing holiday an extra day, had climbed the area's second highest peak and were headed down toward a mountain lodge. At 10,500 feet, they spotted the upper part of a body protruding from the ice. It was face down in a small depression and apparently naked.

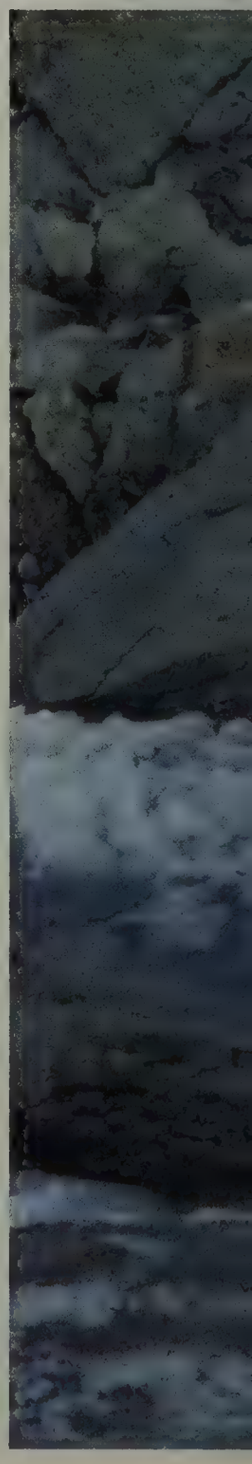
Everyone's assumption was that this was the body of a climber who had suffered an accident, perhaps some decades ago. The police in both South Tyrol in Italy and Tyrol in Austria were called from the lodge. After the Italian police decided that the find lay outside their territory, the recovery was organized from Austria. Two attempts were made to free the body from the ice, the first on Friday (the day after the discovery) and the second on Sunday. During this time, not only the recovery teams but also several curious tourists visited the site. Whatever objects had lain about the body disappeared over the weekend.

At the nearby University of Innsbruck, Rainer Henn, the head of the forensics department, received a court order to bring the body down for identification. He traveled by helicopter to the site on Monday, September 23. In the meantime, unknown to the authorities, rumors had begun to circulate that the body could be several hundred years old. An Austrian television crew was already on the spot when Henn arrived.

Henn had been told that the body had been freed from the ice and was ready to be collected and transported. But during the previous night, the water in which it was lying had refrozen, and Henn had to free the body using the equipment at hand, which happened to be an ice ax and a ski pole. The operation took place in front of the television cameras.

Henn immediately realized that the body was not typical of those usually retrieved from glaciers; moisture had not turned the tissues into the fatty, waxy substance known as adipocere, or "grave wax." This body was dehydrated. But there were no obvious signs that it might be very old. Just before the body was loaded aboard the helicopter, however, someone at the site discovered a small flint knife with a wooden handle. People who had found other artifacts at the site soon brought them forth; these included an ax, whose head later proved to be of copper. The next day, Henn and archeologist Konrad Spindler held a press conference: based on inspection of the artifacts, the world was told that the body belonged to a man who had perished 4,000 years ago. Several carbon-14 dates that have since been obtained prove that the Iceman, as he is now commonly called, is 5,200 to 5,300 years old, a relic of the late Stone Age.

The find is unusually important because, first, this was not a grave site but something far more rare—the body of a man who died on the spot. The equipment found with him was what he thought he needed for his venture in the high mountains, whereas articles found in a grave may be what those burying the body believed the dead would need in the afterlife. Second, the artifacts, including things made from perishable organic materials, such as wood, fur, and grass, are extremely well preserved, although most of the Iceman's clothing is rather torn. Third, several of the artifacts are unprecedented finds, such as the wooden handle of the stone knife and the handle of the copper ax-head.



Political complications arose because the body was discovered exactly on the border between the Schnals Valley in Italy and the Ötz Valley in Austria. The confusion was directly related to the melting of the glacial ice that revealed the Iceman. Generally, the border follows the watershed. The Iceman lay to the north of the watershed and therefore appeared to be on Austrian soil. But when South Tyrol was incorporated into Italy in 1919, the mountain passage where the Iceman was found was covered by a glacier, and so the border was defined by a series of border posts. When Austrian surveyors reexamined the posts a few weeks after the discovery, they realized that the site was about 100 yards into the Italian side.

By then, the body had been moved to Innsbruck and stored under conditions approximating those in the glacier (21° F and a relative humidity of 98 percent). Any attempt to move it risked causing deterioration because the body was a "cold mummy," not completely dried out. Negotiations were therefore carried out between the University of Innsbruck and the autonomous province of South Tyrol, both of which agreed that the find had to be examined on a broad, international basis. An agreement was signed stipulating that the research on the body and artifacts would be organized by the University of Innsbruck, at least for a period of three years, with the artifacts to be conserved at the Central Museum of Roman and Germanic Antiquities in

Mainz, Germany. Some one hundred scientists are working on his project, under the supervision of a new department headed by the university president. Two lines of research are being pursued: the one in which I am participating is directed by anatomist Werner Platzer and emphasizes the study of the body, while the second, directed by Konrad Spindler, concerns the artifacts and their cultural context. Eventually, the archeological finds are likely to be put on exhibit. But the Iceman himself may be kept in cold storage indefinitely to allow medical or scientific research on a Stone Age man to continue many years hence.

The body itself is well preserved, except for the left hip and thigh, which were damaged during the early recovery attempts. Although dried up, the eyes, brain, and intestines are present. The head hair and body hair have been lost because of the long period in the ice, but strands of wavy brown or black head hair have been found among the equipment; they are about 3.5 inches



Climbers examine the body of the Iceman, uncovered more than 5,000 years after his death.
Paul Hanny; Gamma Liaison



The Iceman's hand (top) lies near his knife and ax. The pencillike tool has a central splinter of bone or antler, useful for sharpening stone tools by pressing off small flakes.
SNS/Sipa

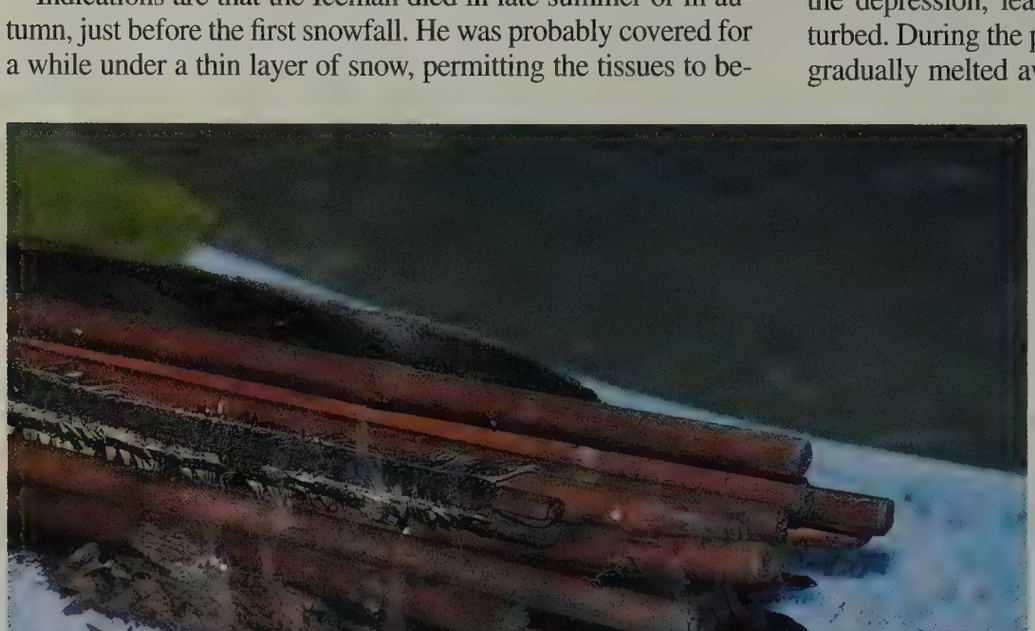
long, indicating that the hair had been cut. On the back and on the legs are patterns of short, dark lines resembling tattoos.

The Iceman's teeth are very worn, and a broad gap separates the two upper middle incisors. The upper lip has receded and the soft part of the nose has been pressed flat. In addition, the shell of the left ear is bent, leading scientists to speculate that the Iceman fell asleep, probably out of exhaustion at the high altitude, while lying on his left side, and froze to death in this position. Later, the body probably rotated to lie on the stomach. The Iceman's age at death has so far been conservatively estimated at between twenty-five to forty years.

A fortuitous combination of circumstances permitted the Iceman to reach us. He lived in a fairly warm time period, when the permanent snowcaps lay several hundred feet above the discovery site. By chance, he must have died just the year the climate changed, with the Alpine glaciers starting to grow and the snowcaps reaching farther down the mountains. Even though the climate varied during the thousands of years to follow, the Iceman did not emerge from the ice until the warm summer of 1991 (if he had, he would not have been so well preserved).

Indications are that the Iceman died in late summer or in autumn, just before the first snowfall. He was probably covered for a while under a thin layer of snow, permitting the tissues to become almost completely dehydrated by the wind. As the snows of the first winter gradually changed into ice, the glacier grew above him, covering him for more than 5,000 years.

Because the weight of the ice and the accumulation of new snow each year forces the Alpine glaciers to move gradually down into the valleys, where they melt, glaciologists had assumed that the region's ice was no more than 1,000 years old. But the Iceman was lying in a little depression between two transverse ridges of rock. Apparently the glacial ice passed over the depression, leaving what was lying on the bottom undisturbed. During the past seventy years, however, the thick ice has gradually melted away. As a final impetus, a dust storm in the Sahara Desert in March 1991 sent large amounts of dust up into the atmosphere, depositing it in the Alps and elsewhere. The dust darkened the white snow, combining with the warm and sunny summer of 1991 to speed up the melting process. The Iceman probably emerged at most three days before he was discovered. Even before he was removed, the season's first snowfall covered the site.



The Iceman's equipment included two arrows and a dozen extra shafts.
Rex USA

The Iceman's equipment, in addition to the flint knife and copper ax, includes an unfinished, seventy-one-inch longbow (eight inches longer than the Iceman himself); a quiver of leather or fur with two arrows—complete with three steering feathers and flint arrowheads—and twelve shafts for making more arrows; a leather pouch; and a frame to some kind of rucksack. The remains of his clothing consist of patches of fur from red deer, goat, or chamois that were sewn together, as well as shoes. This past summer, archeologists

visited the site to complete their excavation and discovered a r cap behind the rock on which the Iceman had been lying. The p is well preserved, with the hairs of the fur still attached.

The Iceman's shoes had been lined with grass. In addition he rried several threads and ropes made from grass and some kind plaited shoulder cape of grass, perhaps used as a raincoat. uitable kinds of wood were used in making the equipment: yew r the bow and ax handle, viburnum for the arrow shafts, ash for e knife handle, hazel for the frame of the rucksack and for stiffning the side of the quiver, and larch for crossboards of the cksack. Why the Iceman carried an unfinished bow—it had ever been strung—remains a mystery.

Two lumps of tree fungus joined by a composite leather strap ere first thought to belong to a species commonly used for tinr, but they turned out to be a different species, most likely choen for its antibiotic properties. Some of the contents of the ather pouch, on the other hand, seem to be remains of the kind f fungus used as tinder. Two grains of a primitive kind of wheat ere found among the remnants of the clothing, showing that the ceman was connected with communities practicing agriculture.

The farmers who now live in the adjacent Schnals Valley in outh Tyrol are familiar with the mountain passage where the ceman was found: they used to drive their sheep to pastures orth of the watershed, where they possessed grazing rights even fter South Tyrol was incorporated into Italy. According to the ost accepted current theory, the Iceman himself could have een a shepherd. The copper ax—something of a luxury item—einforces this theory, for in certain societies shepherds enjoyed high social status. Although domesticated animals were comon at the time the Iceman lived, they robably were considered valuable, and he task of guarding them could have been n important responsibility.

We still do not know for sure why the ceman died, but exhaustion seems likely. n order to understand what the Iceman nay have experienced, in late August of ast year I climbed to the site from the earest villages in the adjacent valleys. From both the north and the south, marked oot paths lead to the mountain lodge, which lies at 9,900 feet. From there one an continue for about 45 minutes along he side of a mountain ridge to the site. This approach is safer than directly crossng the mountain passage where the Iceman was found, where there is a risk of rockslides.

My first ascent was from the north, from about 4,600 feet below the site. I was dressed for normal high Alpine hiking, with solid boots, an anorak for protection from the wind, sun cap and sun block to combat the strong sunlight, and sunglasses because of reflection from the snow at high elevations. After I had walked two or three hours through the valley, the path became steeper. The sunshine felt warm, and the temperature may have been about 45° F. After hiking for another two or three hours through a rocky landscape and crossing a tongue of glacier at the upper end of the valley, I reached the lodge. I felt quite exhausted, in part owing to the thin air at that altitude. Because of a sudden thunderstorm, I waited until the next day and then continued on to the site.

The hike from the south was quicker, but the path was steeper. The 4,900-foot climb took about three hours and was extremely tiring. The last third of the way was along a serpentine path to the lodge. During my ascent, I observed some clouds lying fairly low in the mountains. When I was almost at the top, the clouds suddenly rose from the valley and I was enveloped in a white fog; the temperature dropped markedly, to below freezing. I rested in the fog for a while and proceeded to the lodge when the visibility improved. I considered it too risky to continue to the site in the fog, so I returned to the village instead. That very night it rained heavily in the valley, and the season's first heavy snowfall fell in the mountains.

I imagine the Iceman may have encountered a similar situation 5,300 years ago. If he had just climbed to the top of the mountain passage, he would have been quite tired. He might then have been caught in a fog, lain down, and fallen asleep while waiting for the fog to dissipate. If later on it started to snow, he could have been chilled and, remaining unconscious, fallen into his eternal sleep. □



The black mass in the Iceman's pouch is tree fungus, probably used for tinder.
Gerha Hinterleitner; Gamma Liaison, Paris

Neptune's Ice Age Gallery

A Mediterranean sea cave preserves artwork painted 27,000 years ago

by Jean Clottes and Jean Courtin



In 1985, Henri Cosquer, a professional deep-sea diver, discovered a narrow, underwater opening, barely nine feet by three, beneath the base of a cliff rising from the Mediterranean Sea. Located in the Calanque area between Marseille and Cassis, the cave was 110 feet below sea level. Cosquer dived down several times and cautiously explored his way along a 450-foot-long sloping gallery. Eventually he emerged in a huge, air-filled chamber with many stalactites and stalagmites. However, it was not until a return dive, in July 1991, that he happened to notice the silhouette of a handprint on the cave wall—a common feature of Paleolithic art, made by blowing or spraying pigment around the artist's hand. After photographing it, he noticed two more handprints. Sometime later he returned to the cave with friends to search for additional artworks. This time the explorers began to discern many paintings and engravings of animals on the rock walls.

News of Cosquer's discovery of apparently prehistoric cave paintings circulated among the diving community, and on September 1, three divers from another region went into the cave on their own, could not find their way out, and died there. Hoping to prevent further accidents, Cosquer belatedly reported his discovery to French government officials and submitted photographs that reached us through the Ministry of Culture.

Judging from the pictures he had taken, the paintings and engravings seemed genuine. Many were partly obscured by bright, white calcite deposits, and most of the engravings seemed to be covered by a patina, formed by a natural process that requires long periods of time. However, we could not authenticate the art unless we could examine it directly.

An expedition would require investigators who were both specialists in prehistoric rock art and experienced divers, an uncommon combination. Our exploration of the painted chamber was organized in late September 1991 by R. Lequément, director of the Department of Submarine Archaeological Research (DRASM) and included Cosquer, archeologists from DRASM, several divers from the French navy, and coauthor Courtin.

Even after only a preliminary inspection, Courtin became convinced that the art was genuine. All the figures were weathered, so that when they were examined under a magnifying glass, numerous minute bare spots were visible where the ancient pigment no longer adhered to the cave walls. Many drawings were coated not only with calcite but also with small stalactites that had grown on top of the coating. A patina, often the same as that of the surrounding walls, partly filled in engraved lines of the petroglyphs. Microcrystals had formed on them as well. On the walls were dozens of animal figures, a number of stenciled hands, and thousands of tracings made by human fingers in the once-soft surface coating. A hoax was out of the question. This was a major find.

A close examination of its contents showed that the cave had not been lived in. Two fires had been made but they were quite small, about a foot in diameter, and no bones or flint flakes could

Three marine birds painted in black on a ceiling of the Cosquer cave are believed to represent auks. One auk painting (at bottom left) was partly destroyed when a section of the cave's surface coating fell.

All illustrations courtesy of the Ministère de la Culture, Direction du Patrimoine, France. Photographs by A. Chené, Centre Camille Jullian (C.N.R.S.)







be seen around them. Unlike hearths found in Paleolithic cave dwellings, usually surrounded by a large amount of refuse from human activities, these fires were used for light, not cooking. Hundreds of pieces of charcoal littered the hard calcite floor, probably the remnants of torches used by the Paleolithic artists.

Stéphanie Thiébault, of the National Center for Scientific Research, examined a number of charcoal samples from the site and determined that they belonged to two varieties of pine (*Pinus silvestris* and *P. nigra*) that no longer grow in the Calanque area; nowadays the Alep pine grows there, but this species was not found among the charcoal we analyzed. A preliminary pollen analysis by Thiébault's colleague Michel Girard also revealed that the ancient cave painters had inhabited a bleak landscape with only a few species of trees, among them *P. silvestris* and birch. Radiocarbon dating methods applied to the charcoal samples indicated that they were 18,440 years old.

These analyses confirmed what Courtin's on-site observations and the photographic studies had already indicated: the art was genuine, and it belonged to a pre-Lascaux period. However, after the discovery was announced in late October 1991, a few specialists publicly expressed doubts about its authenticity. Despite the fact that our evidence had been made public, the controversy went on for months, petering out only after we published a comprehensive technical analysis of the cave in July 1992.

One of the main reasons for this lingering skepticism was that a really important discovery does not always fit into familiar patterns of expectation. Sometimes experts find it painful to have to change long-held assumptions. Therefore, whenever a new painted or engraved cave is discovered, its authenticity can be more convincingly established through physical studies and analyses than by comparing the art with what is known elsewhere. To evaluate newly discovered artworks by the comparative method alone would imply that our knowledge of the 20,000 years of Upper Paleolithic cave art is so complete that it cannot admit of any significant modifications.

The evidence tells us that ancient people went into the Cosquer cave during at least two different periods. During Paleolithic times, the sea level was about 360 feet lower than it is now, and the coast was several miles away from the cliff. When the sea rose dramatically at the end of the Würm Glaciation (about 12,000 years ago) and even later—it is still slowly rising today—more than half the cave was flooded. The whole entrance passageway and the lower part of the main chamber remain underwater, but their huge stalagmites and stalactites could not have formed unless these areas had been free of water for a very long time. Some digital tracings in the soft wall surface are covered with calcite and are still preserved underwater, but only for the first two feet. Below that, the walls have been eroded by water and scoured by tiny mollusks. We can thus safely assume that what remains above water is just part of the art in what must have been one of the greatest decorated caves in Europe.

The first period of activity at the Cosquer cave produced the forty-five stenciled handprints and thousands of finger tracings discovered so far. The two forms must be contemporaneous because although handprints are usually on top of finger tracings occasionally it is the other way around. This period can also be differentiated from the one that followed because animal paint



Radiocarbon dates indicate that this male ibex was painted on a low ceiling in the cavern some 19,000 years ago, making it more than 1,000 years older than the paintings at Lascaux.

ngs and engravings are always superimposed on either digital racings or handprints and were therefore made later. What we nave called Phase 1 is now well dated at about 27,000 years ago by four radiocarbon analyses performed in the laboratory at Gif-sur-Yvette, France. In addition, one piece of charcoal found on he ground was dated at approximately 27,870 years ago and an-other at 26,360 years. The late Abbé Breuil, France's premier prehistorian, always attributed hand stencils and finger tracings to the beginnings of cave art; radiocarbon results for the hand-prints confirm his idea of a very early date. In fact, our date of 27,000 years ago is the oldest-known direct date not just for hand stencils but for any painting anywhere in the world.

The hand stencils in Cosquer cave can be compared with those of Gargas, a well-known cave 250 miles away in the Pyre-nees. In both caves, the prints were produced by applying hands to the walls and by blowing red or black paint on top of and around them, so that they left a stenciled outline. As in other pre-historic caves, a majority of the hands seem to have incomplete fingers. Early twentieth-century researchers explained the missing finger joints as examples of ritual mutilation, a gruesome hypothesis that has long since been abandoned. Some later specialists argued that severe frostbite or diseases such as ainhum or Raynaud's syndrome could have caused the loss of fingertips, while others thought they were more likely a sort of sign language such as hunters use. Experiments have demonstrated, however, that the Gargas "mutilations" could be duplicated with normal hands. The Cosquer discovery may put an end to the debate since it seems unlikely that the same disease would have struck different human groups such a long distance apart and, even if it had, that both groups would then have recorded their mutilations on cave walls.

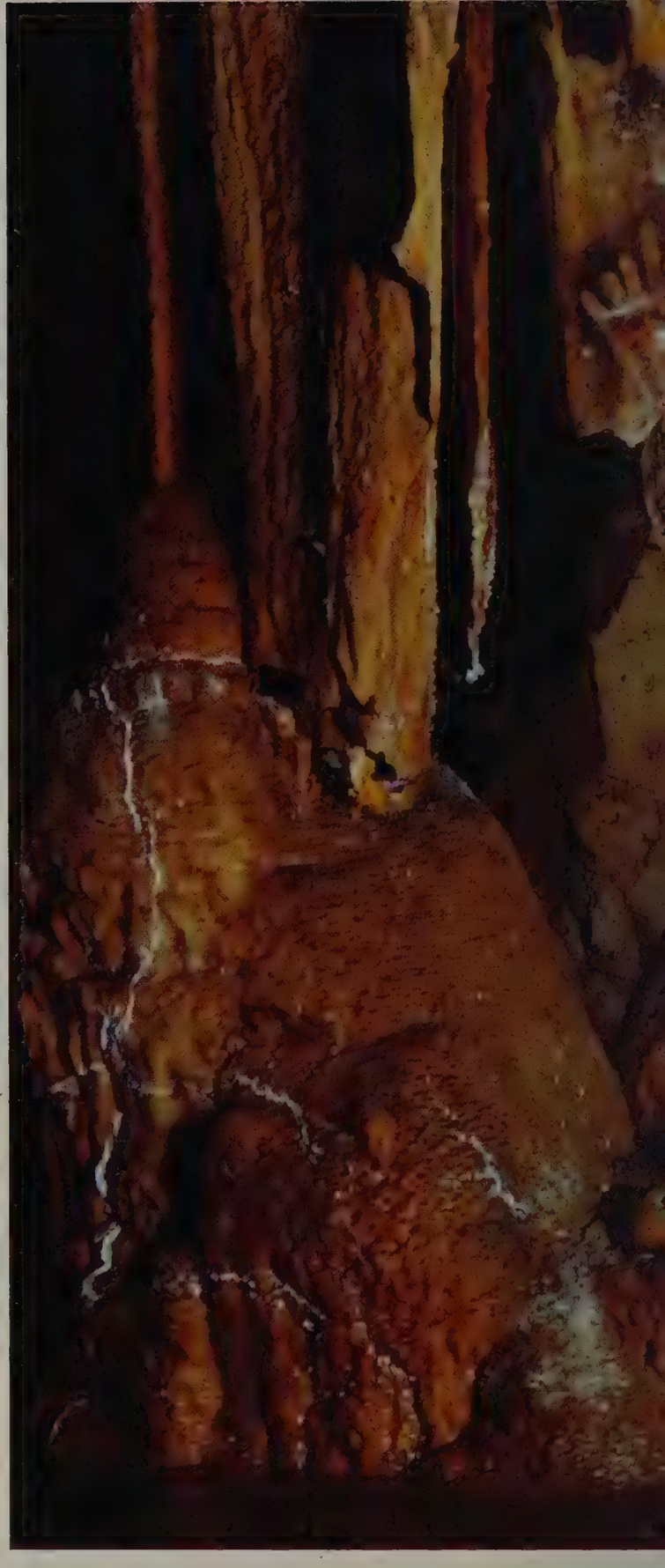
Sixteen of the stenciled hands in the Cosquer cave have been tampered with in one way or another. Some have been criss-crossed with deep engravings and are now hardly visible; sections of the calcite on which other handprints had been painted have been deliberately broken off; red dots or lines have been applied to a few more. Compared with other painted caves, this is most unusual. There is no way to tell exactly when this defacing was done. It may well have happened shortly after the hands were stenciled—perhaps they had served their purpose, whatever it was, and were no longer useful. (However, although ours is an untested hypothesis, we believe much more time passed before the tampering took place. When the people of Phase 2 went into the cave, they could not have missed seeing the handprints that bore testimony to long-forgotten magical practices. They may have wanted to eradicate any power the handprints retained, either by destroying them outright or by putting their own signs on top of them.)

Finger tracings in Cosquer cave have no discernible pattern, and this technique is not used to draw animals as it is in other caves. However, hardly any soft area was left untouched; in some cases digital tracings can be as high up as twelve or even fifteen feet, so getting there may have involved the use of a climbing device. Some wall panels are entirely covered with such tracings, perhaps reflecting a desire to demonstrate possession of the whole cave. The stenciled handprints may also have been a symbol of power and possession, so the conjunction of the two during the same period is probably significant.

Following Phase 1, the cave was abandoned for about 8,000

Stenciled hands can be seen on calcite draperies, right, next to a chasm that extends seventy feet underwater. A few of the images were broken and dots and bars had been added to others. Squat, thick-maned wild horses, below, were dated from pigment samples to about 18,530 years ago. An ibex's silhouette was later engraved over them.





years, unless people used it without leaving any evidence of their presence. We will never know whether this abandonment was deliberate, perhaps because the cave had a reputation for being sacred or maleficent—many such cases are known to ethnographers—or whether it was deserted because the entrance was blocked by rock falls or bushes. Whatever the case, it was probably not abandoned because it was flooded, since so far as we know water entered the chamber only after the end of the last glaciation, thousands of years later.

We believe it was during Phase 2 that all the animal paintings and other engravings were made. This period is well dated at about 18,500 to 19,000 years ago by radiocarbon analyses of the charcoal in some of the paintings, as well as by some charcoal lumps found on the floor. Shortly after the cave's discovery, one of these lumps was dated at 18,400 years old. Another was unfortunately mixed with calcite and sediment and thus gave a less reliable date of between 15,570 and 20,370 years ago. However, three paintings of animals made with charcoal were directly dated (two of them twice) by the recently developed accelerator mass spectrometer. This apparatus requires much less material—about half a milligram of charcoal—than the usual radiocarbon dating technique, and it can therefore be applied to minute charcoal samples from Paleolithic paintings or drawings. Using this technique, the Gif-sur-Yvette laboratory dated the image of a fe line head at about 19,000 years old and a horse drawing at 18,50 years.

Animal paintings and engravings seem to have been placed where they are because of the smoothness and the availability o particular surfaces. Sometimes they appear on a wall and at othe times on a ceiling. In one case, several large animals—one red deer, two horses, and one ibex—were painted in black on a very low roof, barely one and a half feet from the floor, perhaps by a supine artist.

We have now documented about one hundred images of ani





nals. Horses are the most numerous, making up nearly one-third of the total. In some drawings they are represented by a single head; in others, by the whole animal. Such minute details as the difference in coat color between belly and flank are discernible on one painting. On the same panel are three black horses with an ibex engraved over one of them. Horses are the animals most often depicted in other Upper Paleolithic caves, so their dominant presence in the Cosquer cave is not unusual.

The next most commonly depicted animals are ibexes and chamois, animals that favored the rocky environments that existed during Paleolithic times. All but one of the black ibexes are engraved. Their bodies are accurately proportioned, except for the horns, which in some cases are disproportionately large. Male ibex horns grow longer as the animal ages, so representing an ibex with huge horns may have been a way of emphasizing the animal's maleness and possibly its age.

Also represented are several European bison—some engraved, others painted black. Bison are pictured very frequently in Paleolithic art, but some of the Cosquer cave renditions are unusual. In one example, the bison's body is in profile, the horns are seen frontally, and the head is in three-quarter profile. In another engraving the animal's head is lowered as though in readiness to attack. Among the other images found on the cave walls are deer: one buck is painted and two others engraved, as are several hinds. In addition, two strange animals, one painted and one engraved, each with the same massive body and huge hump, seem to be giant deer, rather like Irish "elk." A feline's head painted in black is also present.

One of the most delightful surprises of the Cosquer cave was its depiction of sea animals. A few paintings and engravings of saltwater fish are known in Upper Paleolithic cave art, but drawings that look like seals had so far only been recorded in two caves, at La Pileta and at Nerja in Andalusia. In the Cosquer cave we found three painted auks, eight seals, three strange engraved figures that might be fish, and seven painted sea creatures that resemble either jellyfish or squid. All this is highly unusual and can only be explained by the cave's seaside location. The seals may have had a special symbolic significance, because unlike the other sea animals depicted in the caves, all of them are represented with spearlike signs on top of them.

The unvarying conventions used in the drawing of the land animals lend unity to Phase 2 and tell us that the period did not last long. Bodies are well proportioned but stiff and lacking anatomical detail. Horns and antlers—and at times ears and legs—are seen from the front, in twisted perspective. An ibex's horns bracket a skull that is not drawn in. Legs are always sketchy and spindly, without hoofs, drawn quickly in the form of a Y. These distinctive artistic conventions indicate an early phase of Paleolithic art, well before Lascaux; and in fact the great age



Rising from the cave floor, right, a broad, cylindrical stalagmite bears a large rendering of a horse's head. Below: Indecipherable scratches and finger tracings surround the engraved outline of an ibex. Iron oxide has colored the wall surfaces red, while most of the incised lines in the limestone stand out as white.



of the paintings was obvious on first examination. The radiocarbon datings of Phase 2 came more as a confirmation than as a surprise. The best comparisons can be made with Ebbou, a cave in the lower valley of the Ardèche, about 100 miles west of the Cosquer cave, where similar animal representations have long been known. In Upper Paleolithic times, people traveled, met other groups, and shared their knowledge as well as their goods. Therefore, we find an overall unity in most Paleolithic art, with "styles" confined to definite periods. Recognizable conventions may have been common to contemporary peoples living hundreds of miles apart, while at the same time unique local features arose in various cave paintings. From this point of view, the Cosquer cave does not depart from the norm.

The discovery of the Cosquer cave is an important event in the history of European Paleolithic art—probably the most important discovery since Lascaux in 1940. There are enough animals represented to allow a detailed analysis of the species chosen and their relative importance, of specific artistic conventions, and of the paintings' relationships to one another and to accompanying symbols. Both phases occurred before Lascaux, adding impor tant new data to our knowledge of that period. Even more im portant, the solidity of the new dating provides a baseline for un derstanding the chronology of less well defined sites. Not al departures from the expected norm reflect profound changes i symbolism or culture. Use of sea-animal themes shows the im portance of local environment in influencing the choice of im ages—a lesson that can also be applied elsewhere.

The Cosquer cave will never be open to the public. That cav art should have survived under such conditions is a sort of mir acle, due only to the gallery's being sloped up and the cave's no being flooded in its entirety. Changing the natural conditions tha prevail now could have disastrous consequences for the paint ings, an unacceptable risk. In the next few years, the climate o the cave will be thoroughly studied by means of sensors that wil transmit information from the main chamber to an outside labo ratory. Meanwhile, the cave will remain sealed, although ou photographs enable us to share these remarkable paintings wit the world. □



Faux Lascaux

French artists re-create a prehistoric masterpiece

by Jean-François Tournepiche

As curator at the Musée d'Angoulême in western France, a great deal of my working life revolves around the incredibly rich prehistoric sites that are so abundant in the surrounding countryside. I had prepared many local exhibits about Ice Age art of the Dordogne region, but I never expected to find myself in New York City, re-creating one of France's ancient cave walls at the American Museum of Natural History.

Some 17,000 years ago, a group of Ice Age people decorated the walls of Lascaux cave with images of aurochs (wild cattle), bison, ibex, deer, and other large mammals. Following discovery of the cave in 1940, many thousands of tourists visited Lascaux. Their presence introduced moisture and bacteria, changing the delicate balance of the cave's atmosphere. A destructive film of algae and calcite began to cover the paintings, and in 1963 the cave had to be closed to visitors.

To assuage the public's disappointment, in 1984 the French government opened a facsimile of the cave, known as Lascaux II, in an abandoned quarry near the original. The concrete walls are similar in configuration to those of the real Lascaux. A devoted copyist-painter, Monique Petral, used the same pigments as did the Ice Age artists (manganese, charcoal, and iron oxides) and worked for five years to reproduce the artworks in exacting detail. Although it features only a part of the Chamber of Bulls and the Axial Gallery, Lascaux II is visited by about 300,000 tourists each year.

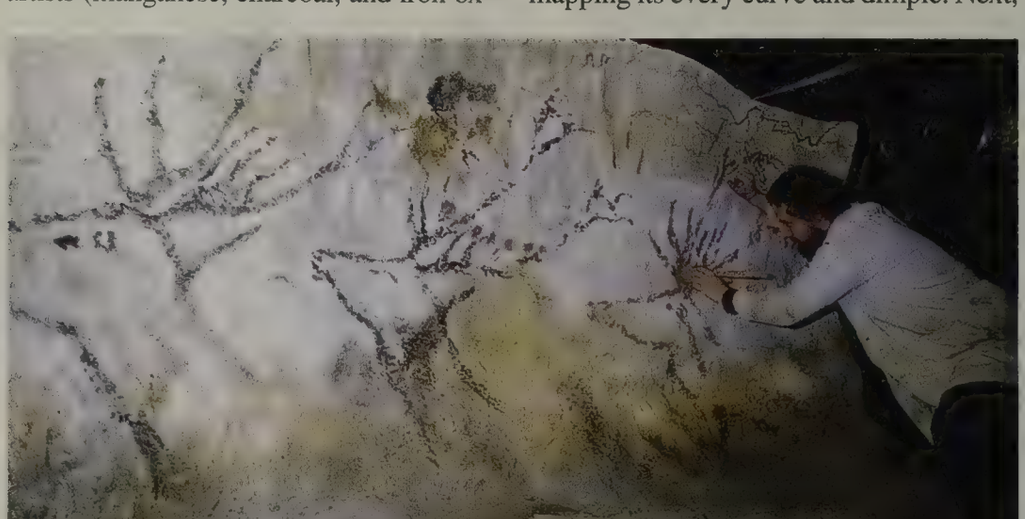
Some years ago, Jean-Philippe Rigaud, the director of antiquities for the Aquitaine region—which includes Lascaux—was asked by the city of Bordeaux to commission a partial replica of the cave, to be displayed at an exhibit in Japan and then returned to that city's Musée d'Aquitaine. It had to be light, sturdy, easy to transport, and faithful to the original. Rigaud chose a frieze that had not been reproduced at Lascaux II: five stags' heads, painted as though the animals were swimming across a river. The frieze is one of the few sections that stand alone, without blending into another group of animal images. Three copies were to be made: one for the Bordeaux museum, one for exhibition near the original cave in the Dordogne, and another for the American Museum of Natural History.

First, we had to create a relief of the chosen wall section. Using a computer, Norbert Ajoulat, a cave art expert, transformed a set of photographs into a series of precise vertical profiles of the wall, mapping its every curve and dimple. Next, our sculptor, Francis Demonsais, modeled a microrelief of the panel out of crushed rock mixed with resin—the most difficult part of the project. Demonsais made a silicone mold of the wall, enabling us to make three identical walls of polyester resin using casting methods similar to those for fabricating sailboat hulls. Finally, with a mixture of crushed earth and natural oxides, Demonsais gave the surface its proper color and texture; powdered gypsum helped to impart a realistic crystalline luster.

Our painter, Anne-Marie Lacaze, projected slides of the stag heads on the cast of the wall. Just as the prehistoric artist did, she outlined the heads with naturally occurring pigments. To be faithful to the originals, she had to be scrupulous and self-effacing while copying the ancient artist's lines.

The finished frieze then had to undergo a rigorous examination by the late Jacques Marsal, one of the cave's principal discoverers and its premier guide and guardian for half a century. More than anyone, he knew the details of the walls—every line and splash of color. Lascaux was his life's work, and he never hesitated to make severe judgments about reproductions of its artworks.

Our team was nervous when Marsal arrived at the workshop of the Musée d'Angoulême. His handshake was cordial but reserved. We watched silently as he scrutinized the outlines, the rendering of the texture, the curve of the antlers. Finally, he said, "There are a few details I don't like, but nonetheless I think this is the best Lascaux copy I have ever seen." Some time later, in October 1992, Anne-Marie Lacaze and I traveled to New York and put the finishing touches on the stag frieze in the American Museum's new Hall of Human Biology and Evolution.



Painter-sculptor Francis Demonsais touches up the Lascaux replica.
Jean-François Tournepiche; Musée d'Angoulême

Jean-François Tournepiche is a curator and head of the exhibition workshop at the Musée d'Angoulême, in France.

ADVERTISEMENT

Rediscover the Caribbean







By Andrew Bill



Rediscover the Caribbean

National Parks • Caribbean Festivals • Historical Sites
Tropical Trail Hikes • Daylong Excursions • Caribbean Cuisine

One thing was made abundantly clear in the Columbus celebrations of last year — he didn't discover the Caribbean, he was just one of the first to rediscover it. The scatter of islands he "found" in 1492 were already inhabited, had well-established and deep-rooted cultures, a wealth of historical treasures and unbelievable natural diversity. Columbus returned to boast the magnificence of the "New World" he had discovered and wrote in his Journal of the First Voyage, "When there are such lands, there should be profitable things without number."

In the five centuries that have elapsed, the Caribbean has undergone many alterations, and yet in many ways it does not seem to have changed at all. The various cultures have been mixed with those of European powers; the historical legacies have been compounded by years of colonial rivalry, religious aspirations and sugar profits; but the natural wonders have been protected from the rigors of the 20th century, while being made increasingly accessible to its visitors. For those who have never been and even for those frequent visitors, there's never been a better time to rediscover the Caribbean.

Blue Iguana, Cayman Islands



COURTESY CAYMAN ISLANDS DEPT. OF TOURISM

MAP: JOE LEMONNIER. COVER PHOTO: BARRIER REEF CAY, BELIZE, © KEVIN SCHAFER/MARTHA HILL. COVER INSETS: (L TO R): SWALLOWTAIL BUTTERFLY, BELIZE, © RICHARD HUNT; THE QUIRIGUA RUINS ON THE CARIBBEAN COAST OF GUATEMALA, © SUZANNE MURPHY – LARRONDE; DANCE OF THE CONQUISTADORES, GUATEMALA, © SUZANNE MURPHY – LARRONDE

From the first moment you set foot on The Cayman Islands, you'll be relaxed vacationers not tourists.



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© SUZANNE MURPHY-LARRONDE

Dancing in the street during the Columbus Celebration, Puerto Rico

CARIBBEAN FESTIVALS

Occasionally there's a celebration that opens a crack in the civilized veneer of an island and lets its true soul shine through.

≈ **Batabano, Grand Cayman** (April 2-3)
A colorful costume carnival up-ends George Town into a weekend's worth of steel bands, parades and dances.

≈ **St. Thomas Carnival, USVI** (April 26-May 1st)
West Indian culture comes to the fore in an exuberant festival of life, music and food in Charlotte Amalie

≈ **Crooked Tree Cashew Festival, Belize** (May 8-9)
The festival celebrates the cashew harvest as part of conservation strategy in conjunction with International Expeditions. Crooked Tree is a colorful village and sanctuary to a large variety of wildlife.

≈ **Loiza Carnival, Puerto Rico** (July)
The small town of Loiza, half an hour out of San Juan, is where the island's African heart beats loudest during a celebration of music and dance.

≈ **Bird watching Olympics, Bonaire** (September 19-25)
At peak migration period keen ornithologists come from all over the world to "spot" as many varieties (189 species is the record to aim for) as possible. Winners take medals.

≈ **Dia de las Razas, Costa Rica** (October 12th)
The day on which Columbus landed in Costa Rica, is the grand excuse for a five-day carnival in the town of Limon.

NATURAL TREASURES

The Caribbean's national parks add a new dimension to sun, sand and sea

As the term "eco-tourism" rings like a church bell through every street and alley of the travel world, most destinations with any pretension to "paradise" have heeded the call. But few have done as much about it as the Caribbean, where even the smallest islands now have protected areas of natural beauty. Some parks are mountainous regions moist with rain forest, or semi-desert terrain prickly with cacti, still others are sub-marine realms whose beauty defies capture by words or camera. These parks are escapes of quiet solitude and havens of interest that are beyond the reach of time.

BONAIRE

The people of Bonaire are quick to point out that their island's beauty consists of two halves. Part of it lies everywhere under the sea, off its coast; the other (dryer certainly but just as wondrous) can be found in its surface nature preserves, most notably **Washington/Slagbaai National Park.** Visitors to the Park can meander through forty square-miles (about one-fifth of the island's land mass) of untouched semi-desert terrain, with clumps of cacti and kibrahacha flowers in bloom. Wildlife is everywhere from the brown boobies hugging the surface of the sea and yellow-winged parrots blending in the branches of mesquite, to iguanas as still as stones. In their breeding season, from January to July, pink clouds of flamingoes are "at home" to visitors.

CAYMAN ISLANDS

Already renowned for their underwater glories, these islands are on the brink of unveiling their newest natural attraction, the **National Botanic Park** on Grand Cayman. When it opens its gates this summer, trails will wind through sixty acres of natural woodland. Heritage gardens will display traditional Caymanian styles of gardening, such as sand yards lined with conch shells, plantations, fruit trees and medicinal gardens. Traditional Caymanian architectural styles are displayed in the various buildings. Eventually Blue Iguanas and the Grand Cayman Parrots, currently being bred in captivity, will be released within the Park.

DOMINICA

On an island that dubs itself the "nature island of the Caribbean" there is the **Morne Trois Pitons National Park,** 17,000 acres lush with rain forest, spiked with mountains and crisscrossed by trails. Visitors to the Park have various hiking options. Guided or walking solo, they can climb through dripping mountain forest up the rocky flanks of Trois Pitons, one of the five majestic mountains in the park (its head is 4,600 feet high and crowned with cloud). Hikers can also seek out the Emerald Pool, which is fed by a delicate cascade and walled with ferns. The second largest Boiling Lake in the world is also located in the Park.

Rainbow over the village of Soufriere, Dominica



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A temple in the Mayan city of Tikal, Guatemala

COSTA RICA

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DOORWAYS INTO THE PAST

Five centuries of colonial rule have left behind a trove of historic treasures

While island destinations the world over boast the sun, sand and sea combination, the Caribbean has several additional attractions to offer the traveler. The Caribbean's long and colorful history, leading from indigenous people to European discovery, has created another dimension over and above that of indolent pleasure, which gives the Caribbean an edge over its island rivals.

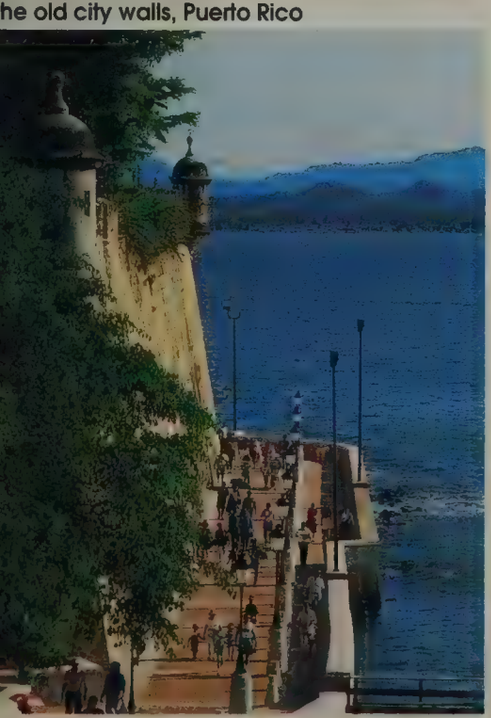
Guatemala

Mention Guatemala and most people think of **Tikal**, the awe-inspiring Maya city that has been wrestled from the jungles in the north. Not many are aware of the country's other historical gems. Along the same lines as Tikal are a handful of sites also in the Petén area — like **Seibal**, **Dos Pilas** and **Aguateca** — all less accessible, but even more atmospheric in their silent homage to a lost civilization. The best places to learn about the human and natural elements at play in these sites are the Archeology and Ethnology and Natural History museums both in the southwest of Guatemala City. The conquistadors, who arrived in the 16th Century and trod the Maya civilization firmly into the past tense, have also been immortalized in the town of **Antigua**, an hour from the modern capital. It retains all the atmosphere of a Spanish colonial town with its tight grid of cobbled streets flanked with pastel facades and a wealth of historical attractions.

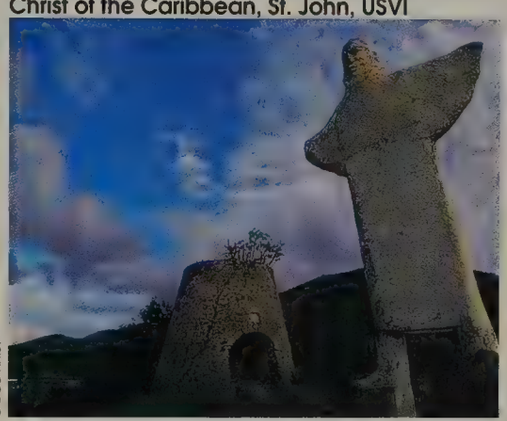
Puerto Rico

Extremely proud of their historic legacies, the Puerto Ricans made a special effort to roll out the red carpet for last year's Columbus celebrations. In Old San Juan, the simple yet splendid home of Ponce de Leon (the island's first governor), **Casa Blanca**, is now open to visitors and the **Dominican Convent**, built in 1523, has been turned into the National Art Museum exhibiting Puerto Rican visual arts. Even new streets, like the **Paseo de la Princesa** along the waterfront, and squares, like the **Quincentennial Plaza**, have been opened to increase the easy ambiance of this living museum. Across the island's mountainous backbone, Ponce on the southern shore has also been beautified. Visitors can now sit at outdoor cafés surrounded by neoclassical architecture in the tree-lined **Plaza Las Delicias**, or stroll through the Museum of Art, the home to one of the finest art collections (local and international) in the Caribbean.

Strolling on the Paseo de la Princesa beneath the old city walls, Puerto Rico



Christ of the Caribbean, St. John, USVI



© BOB KRIST

United States Virgin Islands

Scattered among the USVI's many attractions are a few sites, atmospheric and evocative, where the islands' convoluted history shines through. St. Thomas has **Fort Christian**, its oldest landmark built in 1672 to protect the then-Danish port of Charlotte Amalie. Nearby is **Estate St. Peter**, a beautiful and non-commercial combination of architecture, botanical gardens and spectacular views. St.Croix's vestiges of the past include the 18th-century heart of Christiansted, the capital, and the **Whim Plantation**, a heavy stone house that conjures up, through its antique furnishings and outbuildings, the life of the landowner when sugar was king. Even St. John, the quiet sister of the island group, has a historic complement to its unparalleled natural splendor — the **Annaberg Plantation** which echoes the glory days of the late 1700s.

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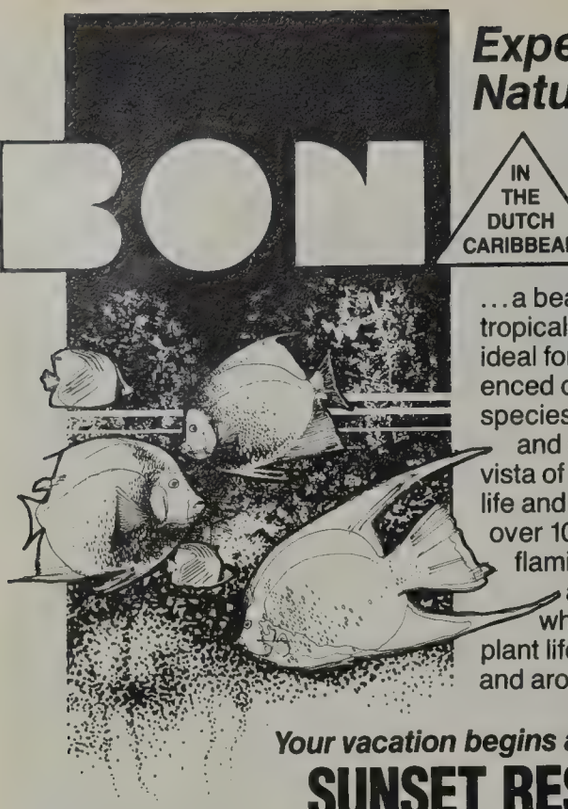
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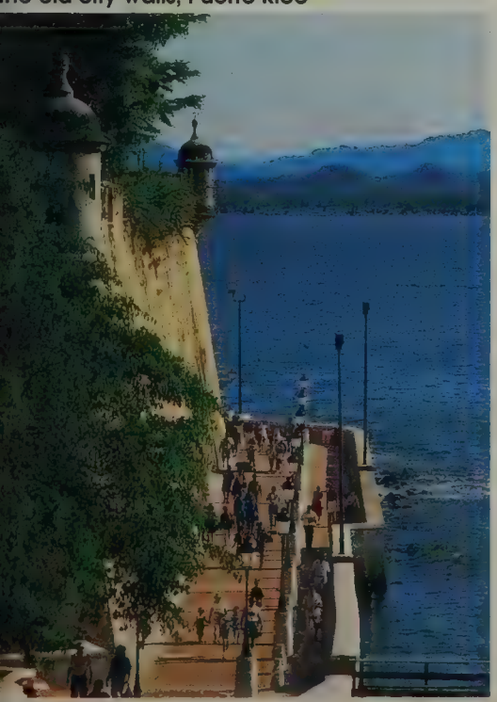
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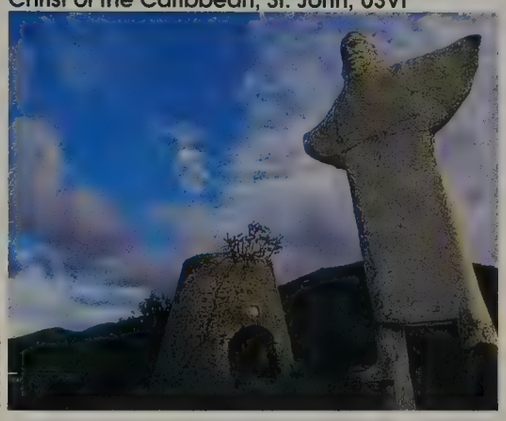
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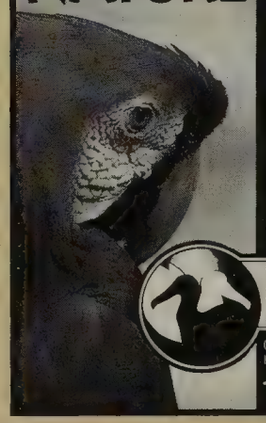
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≈ **Gorda Peak, Virgin Gorda, BVI**
From North Sound Road this trail leads through a national park known for its mahogany trees to a peak which, at 1,500 feet, is the highest point on the island.

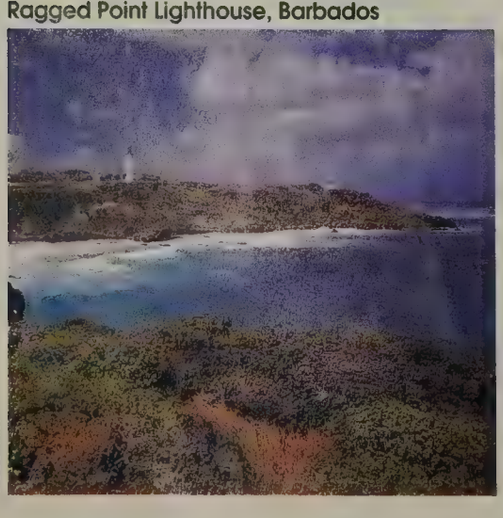
≈ **Sari Sari Falls, Dominica**
A one hour drive from Roseau brings you to the trailhead in the village of La Plaine (where you should find a local guide). 45 minutes later, crisscrossing a river, the path comes to breathtaking falls.

≈ **North Point Hike, Barbados**
An isolated cliff walk around the north end of the island, leading to the Animal Flower Cave, a tidal cave rich with anemones.

≈ **La Mina Falls, Puerto Rico**
An hour in and an hour out of the cool, green shades of El Yunque rain forest, this trail leads to an idyllic pool (perfect for a dip) fed by falls.

≈ **Mt. Brandaris, Bonaire**
Hikers reaching the mountain top , the highest point on the island (784 feet) in the middle of Washington-Slagbaai National Park, can see as far as Venezuela.

Ragged Point Lighthouse, Barbados



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Spider monkey in the Tortuguero National Park, Costa Rica



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Hiker in the Monteverde Cloud Forest, Costa Rica

DAYS OF DISCOVERY

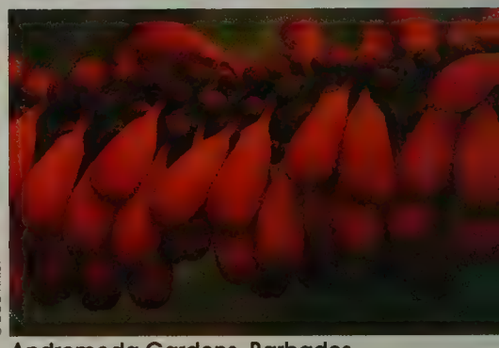
In search of the perfect day-trip

We've all had them, idyllic days just long enough, just full enough to create memories that linger throughout the years — daylong excursions that skewer some of the island's finest sights and experiences into that perfect sightseeing kebab. The ingredients must be a careful blend of activity and inactivity, sun and shade, history and nature, all varied and heavily spiced with sensuous delights, like sunset cocktails on the beach as the shadows grow long. To whet your appetite, here are a few excursions that should pique everyone's interest.

BARBADOS

Early in the morning set off up the west coast to St. Lucy, stopping first at Alleyndale Hall. It is an abandoned plantation house with a profusion of Palladian and Venetian windows, an arcaded verandah, even a resident ghost. Then head southeast to St. Nicholas Abbey, built in 1650 and one of the three Jacobean Great Houses in the Western Hemisphere. Perhaps the owner, Lt. Col. Stephen Cave will show you his father's old home movies of plantation life in the Thirties. Hungry now, drive on to Cherry Tree Hill, stopping to survey the Atlantic and its pounding surf, then along the East Coast Highway to Barclay Park, the prime stop for a picnic.

After lunch proceed south, stopping for a stroll to watch the surfers in the "soup bowl" at Bathsheba, then on to Andromeda Gardens to admire the spectacular flower gardens. By now it's mid-afternoon, time to visit the monkeys, pelicans and turtles in the Wildlife Reserve across the road from Farley Hill, another Great House. As the sunset fills the sky, head west to Speightstown to wander along the waterfront, then stop for a cool drink in a local pub to reminisce about the day.



© BOB KRIST

Andromeda Gardens, Barbados

BELIZE

The day-trip to the Maya ruin of Lamanai starts when you set off from your hotel in Belize City and follow the Northern Highway for the one-hour drive through lush countryside to the town of Orange Walk. Stopping there briefly for a cool drink and some supplies, set out again for one of the nearby towns, Shipyard or Guinea Grass, where you climb aboard a small boat (arranged in advance through your hotel or tour operator). For two hours you motor up a narrow waterway, the New River, with its walls of thick, pristine jungle dotted with color from orchids and morning glories and active with life — monkeys, herons, jacana

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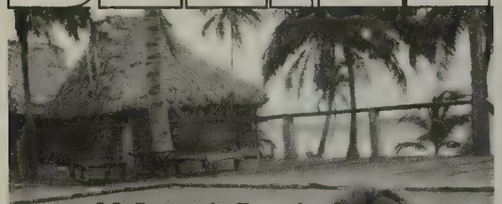
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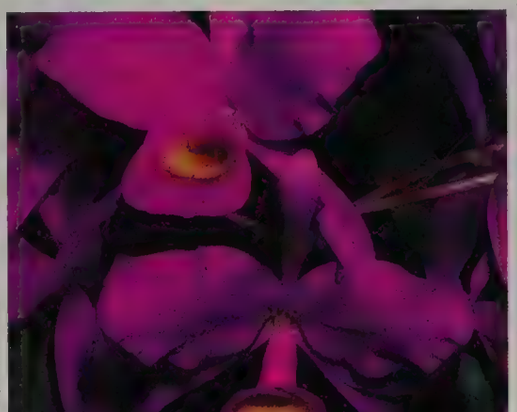
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perhaps even a Jabiru stork (one of the world's largest flying birds with a wing span of up to 12 feet).

As the waters widen into a lagoon, you catch the first glimpse of a pyramid looming above the trees. A short walk later there is the old port city. It is now an archaeological reserve of sixty ancient structures and a mighty temple, the summit of which affords a panoramic view for a picnic. On the way back ask your guide to stop at one of the small villages along the river bank, for a swim and possibly a chat with the locals.



© KEVIN SCHAFER/MARTHA HILL

Orchid, the national flower of Costa Rica

St Lucia

The trip through St. Lucia's green heart centers around the town of Soufrière in the southwest. If staying in the north set off early, (the road is slow-going), to arrive in town in time for a mid-morning refreshment and to join your guide (arranged by your hotel in advance). Then it's on with the boots and off for a hike, tailored to your energy level and preferences regarding terrain, through the thousand shades of green in the primary rain forest. Later, a twenty-minute drive brings you to the open-air restaurant at Ladera Resort whose chef was voted best on the island this year. The resort overlooks the breathtaking Piton peaks and a surrounding sea of lush vegetation.

After lunch take the water-taxi from Soufrière to the gray sand beach at Anse Chastanet for an hour of snorkeling on the reef. Then, in the cooling afternoon, head for the drive through volcano and the Sulphur Springs, stopping to walk abound the crater past spitting natural cauldrons. By now its time to soothe the muscles in the Diamond Mineral Baths, a spa dating back to 1785, set amid manicured botanical gardens complete with waterfall. Finally, if it's Friday, aim for the town of Gros Islet and join the "Jump-Up," a colorful street party and big weekly event for a night of fun and festivities.

For advertising information call Samantha Loomis at Natural History: (212) 599-5555.

LOCAL FLAVOR

Lobster thermidor and coq au vin are all very delicious but it's important for a visitor to try a dish that defines the distinctive flavor of the island.

≈ **Marinated conch, Cayman Islands**
Thin slices of conch saturated in a marinade involving lime juice, Worcestershire sauce and finely-chopped onion.

≈ **Island fish soup, Dominica**
A pot-boil of seasoned fish fillets, lime juice, seasoning peppers and a array of vegetables.

≈ **Flying fish, Barbados**
This delicious white fish is commonly filleted, breaded and fried, then served with a wedge of lime, okra, rice and brown beans.

≈ **Asopao de camerones, Puerto Rico**
Richly spiced but not hot, this shrimp stew served with rice gives renewed vigor into the bodies of locals and visitors alike.

≈ **Mountain chicken, Montserrat**
Don't be fooled, this "chicken" croaks. It's a giant, meaty frog with a lot more flavor than your average fowl.

≈ **Tico tamales, Costa Rica**
The Central American equivalent of the Christmas turkey, these are plantain leaves (rather than corn husks) filled with pork or chicken.

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Of Pandas and Politics

by John Alcock

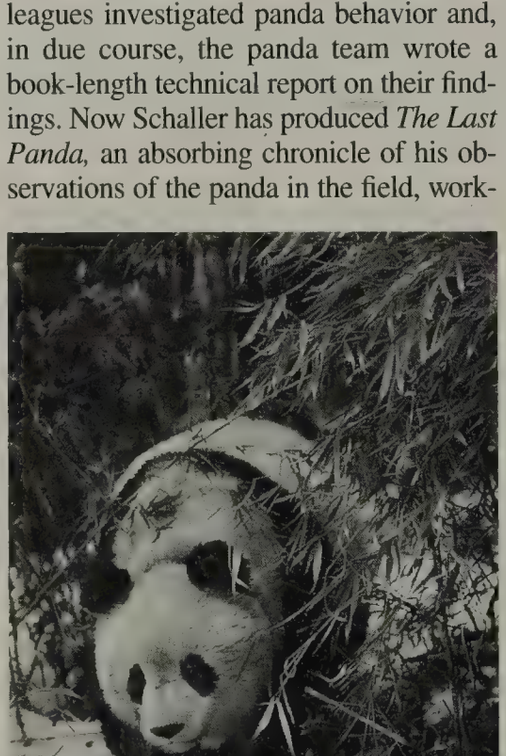
George Schaller has spent a lifetime observing and writing about the behavior of some of the world's most-celebrated large mammals. His scientific career began with the first detailed study of mountain gorilla behavior, which resulted in two books: one a technical report; the other, a wonderful, popular account of what it was like to carry out fieldwork on a potentially dangerous animal under extremely demanding conditions. Ever since *The Year of the Gorilla,* Schaller has continued to pursue challenging, high-profile subjects, such as lions, tigers, and snow leopards, and to write about his findings for his fellow scientists and for general audiences as well, much to the benefit of both groups.

THE LAST PANDA, by George B. Schaller. *University of Chicago Press, $24.95; 352 pp., illus.*

In 1980 Schaller was in South America in the midst of a study of the most-renowned carnivore of South America, the elusive and endangered jaguar, when he received approval to enter China under the auspices of the World Wildlife Fund for Nature (WWF) to study the giant panda. China was just beginning to open up after the Cultural Revolution, and Schaller quickly left jaguars behind in order to take advantage of the exceptional opportunity he had been offered. He tells us of his long-time interest in the panda, an animal which has great emotional appeal to him (and to many other people).

In fact, almost everyone who has ever seen a giant panda in a zoo or photograph considers it to be one of the most lovable mammals. The human desire to cuddle and coo over a panda almost certainly stems from the animal's body shape. It offers what ethologists call a "supernormal stimulus"; in this case, the big head and amazingly rounded body exaggerate the key stimuli associated with healthy human infants, thus eliciting intense parental emotions in some human observers. Pandas are not similarly confused about people. Schaller notes that captive pandas have been responsible for more serious injuries to keepers (on a per panda basis) than all other zoo animals, except elephants. Cuddly they are not. Endangered they are.

In 1980 Schaller knew that the giant panda had been reduced to a remnant population estimated by the Chinese to consist of about 1,100 individuals, not one of which had ever been studied by a Western scientist in its natural surroundings. Schaller hoped that his pioneering research would ultimately help a remarkable mammal in desperate need of protection. For more than four years he and his colleagues investigated panda behavior and, in due course, the panda team wrote a book-length technical report on their findings. Now Schaller has produced *The Last Panda,* an absorbing chronicle of his observations of the panda in the field, working, as always, under extremely demanding conditions.



A giant panda in umbrella bamboo near George Schaller's camp
George B. Schaller

Despite the aura of glamour and excitement surrounding the giant panda in the public mind, Schaller and his colleagues found that the animal actually leads a thoroughly pedestrian life, devoted almost entirely to the consumption of mostly indigestible bamboo upon which pandas feed for hours each day. They interrupt this mundane activity primarily to defecate and to nap. This conclusion required thousands of hours—often fruitless—hunting for these secretive creatures. More than two months passed before anyone at camp even glimpsed a panda. Only after trapping a few animals, a long and difficult task, were the panda team members able to collect any information about their subjects. They did this by attaching radio collars to the captives and then returning them to the wild. Radio signals permitted dedicated trackers to locate pandas and follow them on some occasions, documenting their droppings (ninety-seven one day from one panda) and whatever else they could find. Very rarely was the tracker actually able to watch a panda in action (or inaction).

Despite the sluggish nature of his subject, Schaller's skill as a writer of natural history makes the panda's life and the process of panda study interesting to us. He provides wonderfully vivid descriptions of the seasons in the mountainous Wolong Reserve, where much of the panda research was done. His account (and that taken from his wife's journal) of checking radio locations of three pandas every fifteen minutes, all night long on a frigid mountain ridgeline, gives real meaning to the term fieldwork. Readers of this section are likely to agree with Schaller that field studies are not so romantic as they are cracked up to be. Throughout, we sense the dogged persistence with which Schaller pursues his subject, dealing with frustrations on all fronts, collecting bamboo samples for nutrition

nalysis, weighing panda feces, mapping e ranges over which the radio-collared andas roamed, and waiting for those rare oments when he crossed paths with a anda.

But most of the high drama is provided ot by the giant pandas that Schaller saw nly occasionally but by the people whose ves touched those of pandas, people who ere generally more active and always ore Machiavellian than the pandas hose fate they affected. Among these layers were officials at WWF, the Chi-ese bureaucrats with whom Schaller and WF negotiated, the Chinese peasants ho killed pandas inadvertently in snares t for other game, the recent graduates of hinese universities assigned to assist challer in studying the panda in the field, nd the lumbermen who are rapidly clear-g the last isolated mountain forests in hich the few remaining pandas live. The ast of characters extends to zoo adminis-ators around the world, Chinese officials ho rent out pandas to zoos for temporary nd highly profitable exhibition, Ameri-an politicos—including Henry Kissinger nd George Bush—who have wanted to apitalize on panda popularity, the U. S. ish and Wildlife Service, the directors of aptive breeding facilities for pandas in hina, and the Japanese and Taiwanese ho are willing to pay thousands of dol-rs for a single stuffed panda pelt.

The Last Panda is really more about ese people than about panda behavior er se. The complex human story that challer skillfully tells is fascinating, al-eit depressing. It is composed of equal arts greed, stupidity, mismanagement, esperation born of poverty and overpopu-tion, miscommunication, culture shock, nd good intentions that may have helped ave the road to the panda's premature ex-nction in the wild. It is a story rich in sad onies. To take just one example from the any that Schaller describes: The intense esire of WWF (for whom the panda erves as the institutional logo) to promote panda research enabled the Chinese to extract a large sum of money from that organization, a sum that the Chinese decided to invest in an expensive, high-tech panda research center at Wolong. Schaller felt right from the start that these facilities were not needed, but the Chinese had their way. Other provinces subsequently demanded and succeeded in acquiring funds for the construction of their own panda research centers and breeding facilities. To justify the existence of a panda bureaucracy, a considerable number of pandas have been captured and taken from their mountain homes to the breeding facilities, removing them from places where they are perfectly capable of breeding successfully without human assistance—provided that their mountain habitat is not leveled by lumbermen or invaded by an army of poachers. To date, the breeding facilities have had little success, so little that it is likely that their creation has harmed, rather than helped, panda survival.

Moreover, by 1987 (just a few years after Schaller left China) the Wolong Research Center had fallen into disrepair. As one WWF analyst reported, "we have little tangible evidence of success" in return for WWF financial contributions on behalf of panda conservation. As Schaller himself notes, "Our years of intensive effort to protect the panda have certainly not yielded a victory and perhaps only a modest postponement of defeat."

Thus, readers hoping for an optimistic tale, in which science and conservation triumph over all, will be disappointed. The title of Schaller's book provides a clue as to the probable imminent fate of the giant panda. Even if the Chinese authorities eventually do try to implement a detailed conservation plan for the panda that WWF made available to them in 1989, the continuing growth of China's immense human population probably dooms most large, rare mammals.

Still, although the story that Schaller has to tell cannot be called uplifting, it is instructive and may help open the eyes of those interested in international conservation projects. After reading the panda's story, one has to wonder whether wildlife conservation really is advanced by attempts to save single species of high emotional appeal.

Pandas have unquestioned power as an emblem to attract donors, ranging from WWF contributors to Nancy Reagan, who gave the Chinese government $9,589.93 raised by American school children in a "Pennies for Pandas" program. But had Nancy Reagan, the WWF, and others been able to donate even a fraction of the amount they received from a panda-obsessed public toward efforts to protect China's mountain ecosystems, pandas and a host of other animals and plants would have come out ahead. There can be little doubt that if it were possible to promote mountain reserve expansion, so that isolated patches of panda habitat could be consolidated into a single large reserve, and if it were possible to institute effective reforestation and antipoaching efforts in an expanded reserve, Schaller would be much more cheerful about the future of one of humankind's favorite animals. However, according to his grim assessment of the situation, the obstacles facing panda conservationists are overwhelming.

Nevertheless, we can take some comfort in that now, at least, we have an accessible record of the natural history of the panda. This account, by someone with deep affection for the animal, someone who saw beyond the attractive black-and-white exterior of a roly-poly symbol, conveys what it was like to watch one of the last giant pandas eating and sleeping in a snowy bamboo thicket—a place where it really belongs—ignoring its observer and unaware of humans and their designs.

John Alcock is a professor of zoology at Arizona State University and the author of Animal Behavior: An Evolutionary Approach *and* Sonoran Desert Summer.

What's Your Sign?

by Gail S. Cleere

In mid-April, the sun crosses a boundary between constellations, slipping from Pisces into Aries. According to astrologers, however, the "sun sign" of people born in April is either Aries (okay so far) or Taurus, a constellation the sun won't reach until mid-May. The gap between tradition and fact has been growing since the rules for astrology were established by Hellenistic astrologers more than 2,000 years ago.

Over the millennia, the earth's gyration about its axis (called precession) has shifted the timing of the sun's passage through the constellations. Thus the dates assigned to zodiac signs hundreds of years ago no longer reflect what we see in the sky. But this doesn't keep legions of unquestioning believers from planning their lives around the motions of the stars and planets.

The sun's path through the constellations is a circle called the ecliptic. This circle crosses the celestial equator (the plane of the earth's equator stretched out like a disk into space) at two points called the equinoxes, which mark the beginning of spring and fall. Each point is seen against a very specific background of stars—one that shifts over the centuries.

The vernal (or spring) equinox is also called the First Point of Aries—so named more than 2,000 years ago, when this point in the sky was indeed among the stars of Aries. But it has actually been in the constellation Pisces since about 70 B.C. and is now moving slowly toward Aquarius—an "age" that will "dawn" in about 600 years.

While points in the sky cannot be fixed permanently, each gyration of the earth takes so long—about 26,000 years—that the stars appear to remain fixed during our lifetimes. But five thousand years ago, the position of Polaris, our North Star, was filled by Thuban in the constellation Draco; it will be occupied by Vega in Lyra some twelve thousand years from now. In other words, things in the sky are constantly shifting, a fact pretty much ignored by many astrologers today. "We're using the classical constellation boundaries," they say, even though precession may have carried the sun into an entirely different constellation from the one indicated in most horoscopes.

Ancient astrologers believed that a person's fate was determined at the moment of birth by the position of the stars, the five planets then known, the sun, and the moon. Forecasts could be made for kingdoms as well. Even the scientists of the time followed certain astrological principles. For 2,000 years, the study of the planets and the meaning of their movements through the sky was central to Western culture and was considered as rational as the astronomy and geometry upon which astrology is based.

When Copernicus and Kepler destroyed the geocentric world picture, astrology as a science began its slow decline. Since the seventeenth century, the science of astronomy has become more precise, while the pseudoscience of astrology has become increasing inconsistent, with as many different interpretations—and doctored records—as there are astrologers. "A strange combination," one contemporary astronomer puts it, "of fuzzy thinking and pious fraud." Curiously, it persists.

According to astrologers, the constellation occupied by a planet at the moment of one's birth is propitious. But what's the significance of Jupiter's rising in Orion, or Cetus, or Auriga? These, too, are constellations, and the planets sometimes reside in them, but they are universally ignored by astrologers. And what about Uranu Neptune, or Pluto, which were unknov in ancient times when the rules we made? (In London in 1632, mortality st tistics listed thirteen persons who had su cumbed to "planet," more than had be "murdered" or died of "grief." Could t culprit have been a planet that wasn't ev known yet? "I wonder what the sympton were," Carl Sagan mused in *Cosmos*.)

Many attribute the popularity of astr ogy to poor science education and newspapers and magazines featuring a trology but not astronomy. The news th Reagan's White House schedules we planned in secret consultation with a Ca fornia astrologer was unsettling but hard surprising in a country that has ten tim as many astrologers as it does a tronomers. A National Science Found tion survey found that 55 percent of Ame ican adults do not know that the earth go around the sun once a year; interestingly Gallup poll showed that the same percen age believes in astrology. Leif Robinso editor of *Sky and Telescope*, wrote, "If pe ple are that lost in space when it comes understanding the Sun and planets, wh can blame them for accepting whatev astrologers say about them?"

The Astronomical Society of the Paci distributes a pamphlet called "Astronon vs. Astrology," which points out th today, as in ancient times, "a system th connects the bright planets and zodiac constellations with meaningful life que tions is appealing and reassuring. Thin ing of Venus as a cloud-covered dese world as hot as an oven is far less attracti than seeing it as an aid in deciding who to marry."

Meanwhile, those of you with birthda in the first half of April should rememb that the sun was in Pisces when you we

ɔrn, not in Aries. And for those of you ɔrn in the second half of April, the sun as in Aries, not in Taurus.

HE PLANETS IN MARCH

Mercury is a morning object this onth, but difficult to observe in the orthern Hemisphere due to its low altide. The planet reaches its greatest disnce west of the sun on April 5. On the 6th, elusive Mercury is 8° south of neighɔring Venus. On the 20th, Mercury is the me distance south of the moon.

Venus is between the earth and the sun n April Fool's Day (no kidding) and nerges as a morning "star" as the month ogresses. On the morning of the 19th, e thin, waning moon is to the immediate ght of Venus and occults the planet later the day. Although it is a daytime pheɔmenon in North America (except in the orthwest), the occultation is visible with noculars and telescopes. Such events re-ne our knowledge of the moon's orbit nd profile.

Mars is at its closest to the star Pollux is month, closing in at a mere 5° south of is first-magnitude star in the constellaɔn Gemini. Watch Mars' rapid eastward otion all month with the stars Castor and ɔllux as reference points. On the night of e 27th, a waxing first-quarter moon asses below Mars and the twins.

Jupiter rises before sunset, dominates e eastern sky at dusk, and remains visle for most of the night throughout the onth. Just after sunset, look for Jupiter nd the stars Arcturus and Spica forming a right triangle in the east–southeast, then atch the trio travel across the sky until rly morning.

Saturn emerges from the glow of dawn April. As the month progresses, Saturn ecomes easier to see, a bright object against the relatively faint stars of the constellation Aquarius.

Uranus and **Neptune** continue to enjoy their close encounter this year, rising together after midnight in the eastern edge of the constellation Sagittarius. On the 13th, the last-quarter moon passes just above them.

Pluto plods along in Serpens, rising in this faint, meandering constellation well after sundown. Pluto is impossible to spot without a good-sized telescope and accurate sky maps.

The **Moon** is full on the 6th at 2:43 P.M., EDT; reaches last quarter on the 13th at 3:39 P.M., EDT; is new on April 21 at 7:49 P.M., EDT; and reaches first quarter at 8:40 A.M., EDT, on the 29th.

The Lyrid meteor shower peaks just before dawn on April 22. The moon is new, guaranteeing a dark sky, so this promises to be one of the year's best meteor showers. On the average, the Lyrids produce about fifteen to twenty bright meteors per hour, many leaving streaks across the sky. Some years (the last being 1981) have produced tremendous displays—seventy-five meteors or more per hour. On the night of the 21st, start watching for them just after midnight. (At that time, your position on earth is rotating toward the meteor stream, so they appear more frequently). The Lyrids are remnants of Comet Thatcher, which has an orbital period of 415 years and was last seen in 1861. The ancient Chinese first noted the Lyrids in 687 B.C., making them one of the earliest recorded meteor showers.

Gail S. Cleere writes on popular astronomy and is a founding member of the International Dark Sky Association, an organization dedicated to preserving the skies for astronomy.

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AT THE AMERICAN MUSEUM OF NATURAL HISTORY

THE HALL OF HUMAN BIOLOGY AND EVOLUTION

The American Museum of Natural History's new Hall of Human Biology and Evolution will open on Friday, April 23. Among the exhibits are four life-size dioramas depicting our prehistoric ancestors in scenes of everyday life. In one diorama, a pair of australopithecines are walking across volcanic ash in what is now Tanzania, creating the famous Laetoli footprints that have been dated at 3.5 million years before the present. Another scene shows *Homo erectus*-like models butchering a carcass on the African savanna (and driving vultures away from their dinner). A third shows a family of Neanderthals in a rock shelter, preparing animal hides and using stone tools. A fourth grouping portrays Cro-Magnons of the last Ice Age, preparing a meal outside their hut made of mammoth bones and tusks.

Other features of the new hall include a replica of a frieze from the painted cave of Lascaux, in France; a new mural depicting the stages of early primate evolution; a see-through hologram of the nerves, skeleton, organs, and circulatory systems of a woman's body; and an "electronic newspaper" that will keep visitors up-to-date on the latest discoveries in human biology and evolution.

PEACEMAKING AMONG PRIMATES

Ethologist Frans de Waal has studied how chimpanzees and rhesus and stump-tailed monkeys resolve aggression within their groups. De Waal, associated with the Wisconsin Regional Primate Research Center since 1975, will talk about primate peacekeeping gestures on Wednesday, April 7, at 7:00 P.M. in the Main Auditorium. Tickets are $12 ($8 for members). Call (212) 769-5606 for ticket availability.

COMMEMORATING THE CIVIL RIGHTS MOVEMENT

To mark the twenty-fifth anniversary of the death of Martin Luther King, Jr., the Museum will screen *We Shall Overcome*, on Thursday, April 15, at 7:00 P.M. in the Kaufmann Theater. The film traces this anthem from its origins in the Sea Islands to its association with the Civil Rights movement. Tickets are $6 ($3 for members).

The site of the King assassination



A diorama in the new Hall of Human Biology and Evolution depicts a pair of australopithecines strolling across volcanic ash in ancient East Africa.
AMNH

mphis, Tennessee, became the Na-
al Civil Rights Museum in the fall of
1. Its executive director, Juanita
ore, will discuss the institution and its
in showcasing the history of the Civil
nts movement on Thursday, April 29,
:00 P.M. in the Main Auditorium. Tick-
are $10 ($5 for members). Call (212)
-5606 for information.

E HINDU WARRIOR GODDESS

n southern India, worship of the Hindu
dess, Mariyamman—also called Mi-
shi or Kamakshi—has influenced the
us of women in Tamil society. Anthro-
ogist Chantal Boulanger will give a
talk on the deity as a warrior queen
the strong matriarchal traditions asso-
ed with her on Friday, April 30, at 6:30
in the Linder Theater. A graduate of
ole des Hautes Études en Sciences So-
es, Boulanger specializes in ethnology
has done fieldwork since 1981 in the
an state of Tamil Nadu.

TARCTIC ASTRONOMY

ntarctica has become a site for remote
ervatories that scientists hope will be
dels for lunar outposts. James
eitzer, of Antarctica's Center for Astro-
sical Research, will present an illus-
ed talk, "Antarctic Astronomy: Scan-
g the Universe from the South Pole,"
Thursday, April 22, at 7:30 P.M. in the
netarium's Sky Theater. Tickets are $8
for members). Call (212) 769-5900
ut this program and other Planetarium
nts.

IGNED TOUR

The deaf and hearing impaired will
e an opportunity to tour the Museum's
bird halls on Saturday, April 24, at
5 P.M. Group tours are available by ap-
ntment. For further information, call
2) 769-5566 (voice). TTY users call
0) 662-1220 (relay).

se events take place at the American
seum of Natural History, located on
tral Park West at 79th Street in New
k City. The Kaufmann and Linder the-
s are in the Charles A. Dana Education
ng. The Museum has a pay-what-you-
h admission policy. Call (212) 769-
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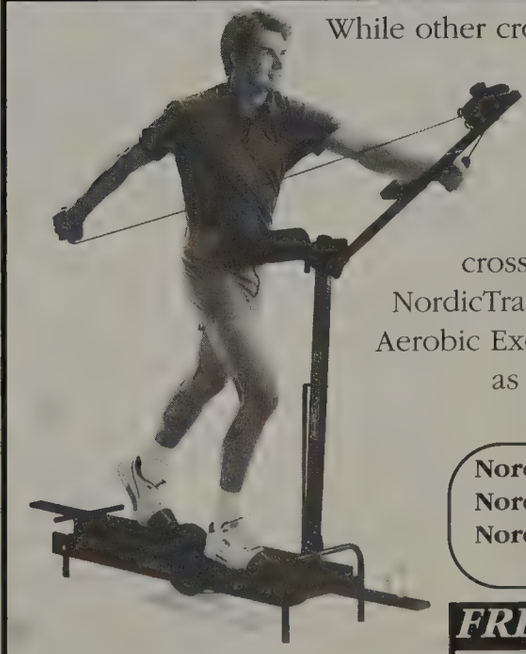
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The Bread Baker's Holy Grail

The path to the perfect loaf is paved with new inventions

by Raymond Sokolov

One recent morning I awoke from pleasant dreams to find my wife in the kitchen making mudpies. Drawing warily nigh, I determined that she was in the early stages of an all-consuming experiment in baking bread. I thought I knew a thing or two about this, as an alumnus in good standing of the back-to-basics culinary movement of the sixties.

Indeed, I had cut my teeth in the kitchen by baking many loaves of bread. In those days, I earned my living as a book reviewer, so bread baking offered an energetic series of brief breaks in between long stretches of reading. I would activate a package of dry yeast in warm water, then work it into a mixture of all-purpose flour and water to make a bread dough. After two or three hours the dough would rise, doubling in bulk, at which point I would punch it down, knead it briefly, and let it rise again, usually in a loaf pan. Then I would bake it, and others would goggle with amazement at my handiness.

All the while I knew in my heart of hearts that my bread was only a small bit better than the limp stuff found in supermarkets. Its texture, or "crumb," was an improvement on commercial Kleenex bread, and my crusts were crisper even than the so-called French loaves on sale in my neighborhood. But still, there was much better bread than that in the world. Real French bread in a good Parisian bakery, for example. Or certain crusty loaves sold as peasant or farmhouse bread in better gourmet shops. So if I had poked around a bit even then, I would have discovered a burgeoning world of superior bread baking right in my own backyard.

Twenty years later that world has come of age. In almost every major city there is at least one major-league-quality baker. And for the home hobbyist, there is a growing literature of advice and counsel, as well as an array of special equipment. It was this world that had kidnapped my wife's attention. Those mudpies were sourdough "chefs," or starters, simple mixtures of flour and water and salt that served as little laboratory forcing grounds for the development of "wild" yeasts present either in the air or the flour, which was a special "hard" variety ideal for bread, flavorful and perfect for a serious crust and an *al dente* crumb.

After the starters had started, they were fed more flour in a couple of stages, and eventually we got a loaf-shaped piece of dough. I am collapsing here several pages of instructions that my friend Jeffrey Steingarten kindly sent me. This *samizdat* supplement to his November 1990 *Vogue* column on bread strongly suggests weighing out the flour and testing internal temperatures. So we soon acquired scales and an instant-reading thermometer with a sharp point for sticking into the loaf, not to mention various razor blades and other sharp instruments for slashing the top of the dough just before it went into the oven. We also procured well water so that the action of wild yeast and bacteria in our chefs would not be undermined by chlorine.

Finally, there was the matter of the oven. Ah, yes, the oven. Ours, a brand-new electric model, had been chosen for its accurate, dry heat. But the literature, from Elizabeth David through John Thorne (and, of course, the exigent Steingarten), made anything less than a wood-fired brick oven sound sterile and politically incorrect. But there is a way out of this bind: Sassafras's Superstone La Cloche, a bell-shaped, unglazed ceramic baking cloche that fits inside a modern oven and simulates the steamy enveloping heat of a brick oven. Not only that, as all acolytes of the True Way inevitably g around to pointing out, there is a pho graph of an extremely similar cloche exc vated from the Agora at Athens repr duced in Elizabeth David's *English Bre and Yeast Cookery* (Viking, 1982), a bo that is the moral equivalent of the Serm on the Mount for True-Way breadies.

While she searched for the Sassafr grail, Mrs. Sokolov developed her ov method of steaming things up. (She leav a cast-iron skillet in the lower level of t oven while it preheats. At baking time t bread goes in the upper level. Then s pours two cups of boiling water into t skillet and quickly closes the over doo Eventually, however, a call to the om scient 800 operator turned up a number the Sassafras company, and soon the after a package containing the special ve sel appeared at our doorstep. I am happy say that remarkable bread emerges from with regularity, if not like clockwork.

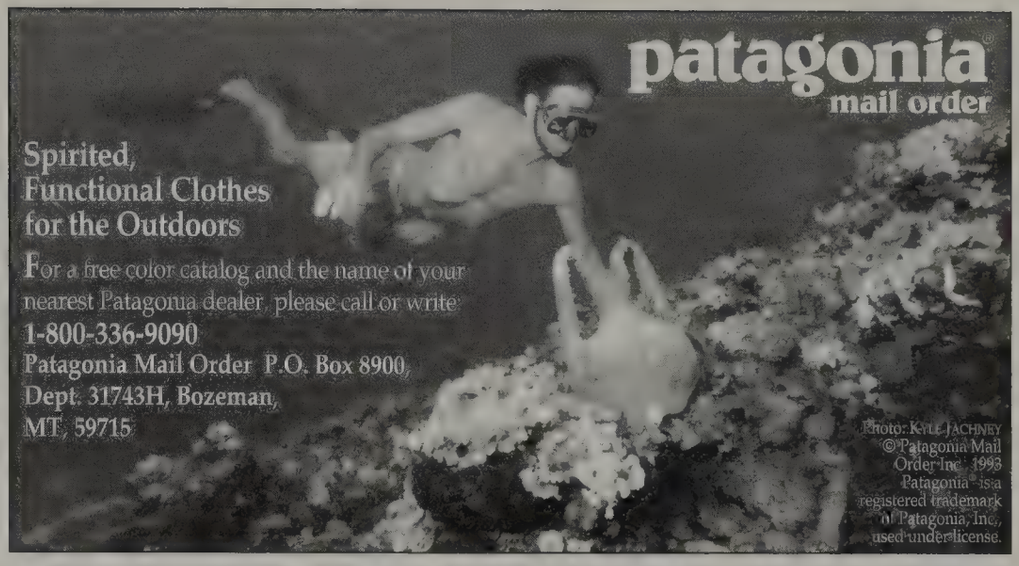
Of course, I am delighted. But I am a a bit let down by the repeatability of t process. The breadie literature had ma me think that Mrs. S. was embarking on unpredictable home adventure. Jo Thorne is eloquent about the risks of se ous bread baking. He isn't kidding wh he says: "Success cannot be guarantee And Thorne is no armchair baker. This someone who, after all, had a ceme core, wood-fired oven installed in his ya when he lived in Maine. He positively re els in the uncertainty of wild-yeast brea making. And, to make his point as clea as possible, Thorne has adopted a word must have picked up in France—"a sanal." The word isn't in every dictiona but it comes up all the time in France places where people are making a point turning their backs on industrial produ in favor of a sturdier, more traditional a

oach to making food or clothes or furni-
re or what have you. In the same con-
kts, speakers of ordinary English would
y "handmade" or "homemade" or
raftsmanlike." Thorne does himself a
sservice with "artisanal," because he
akes something admirably simple and
sic sound rarefied and fancy.

This is perplexing because Thorne's
ain purpose seems to be to get his read-
s to follow their bliss in the kitchen,
andoning the lock step of Cartesian
cipes for Rousseauean freedom and the
oral challenge that comes with it: "Why,
en, would anyone *prefer* a natural leav-
ing?" he asks, after outlining the serious
d constant risk of failure. Then he an-
vers his rhetorical question:

response, it might be argued that at the
ry center of the artisanal process is not so
uch insistence on fine ingredients nor
astery of any particular method, but rather
willingness to assume personal responsi-
ity for the thing made. Paradoxically, this
eans surrendering control, for there can be
responsibility without risk of failure. But
llingness to assume that risk restores the
ker's artisanal status even as it offers the
ssibility of creating an incomparably
usty and full-flavored loaf.

Thorne publishes his food essays in a
wsletter called "Simple Cooking." He
ems to assume his audience is composed
literate foodies. So he is not writing for
aditional, nonmeasuring, nonrecipe-
ading cooks who are unreflectingly arti-
nal but extremely unadventuresome,
nce they normally just want to repeat
nat they already know. Thorne is un-
owedly addressing himself to commit-
d hobbyist cooks who normally work
om cookbooks. As I read him, Thorne
inks these people are practicing a soul-
ss pseudoscience, instead of a fully real-











Wild Yeast Sourdough

(Abstracted from *Outlaw Cook,* by John Thorne, Farrar, Straus & Giroux, 1992)

The *Chef,* or Starter

(Based by Thorne on the method of Lionel Poilâne)

1. Pour one-half cup of (unchlorinated) water into a bowl. Work in enough flour to make a "moist but cohering dough." Practice will make this stage obvious: when the soupy slurry turns to a solid, puttylike mass that can be massaged (kneaded) into a small, elastic ball. Please note that no commercial yeast has been added. This starter will ferment, if it does ferment, because of the presence, either in the ambient air or in the flour, of naturally occurring yeasts and symbiotic bacteria.
2. Put the starter in a small bowl. Cover with a damp dish towel secured by a rubber band. Leave on a shelf in a draft-free kitchen for three days, remoistening the towel as needed (and when possible: clearly, the atmosphere in your kitchen may dry out the towel so rapidly that only round-the-clock surveillance will really keep the towel constantly moist. Eternal vigilance is impossible, but do your best. Also please note that no kitchen temperature is specified, since you will probably have to work with what you've got. Unheated kitchens in severe winter weather are obviously not the ideal, but the normal range of temperature in a modern home should work in something like the times specified here and below).
3. The starter is activated when it looks and smells active. Fermentation produces a noticeable expansion in its size and a slightly "tangy" odor. It can then be used or refrigerated for several days.

The *Levain,* or Sponge

1 8-ounce starter
2½ cups flour
½ tablespoon sea salt

Put the starter in a bowl with 1¼ cups cold water (cold to slow the fermentation, on the theory that a long rising at this point improves flavor and, because it relaxes the gluten, makes the job of working in the water easier). Work until the starter has completely dissolved. (Thorne uses his hands; an electric hand beater is much more efficient. Just add a little water at a time.) Stir in the flour and the salt to make a loose mass. With floured hands move it to a clean bowl. Cover with a damp towel and a piece of plastic wrap. Secure with a rubber band and leave to ripen overnight in a cool place (Thorne specifies 60 degrees).

The Loaf

1 sponge
Flour
Cornmeal

1. Put the sponge on a well-floured surface. Begin to work in the new flour. The idea is to knead in as much flour as the sponge will "take" until it turns into silken, nonsticky dough that is a pleasure to work. No amount of flour is specified. The limiting factor is the 1¼ cups of water added at the sponge stage. This kneading stage takes 12 to 15 minutes, during which the movement activates the elasticity of the gluten and traps air in the dough so that the yeast can do its work.
2. Dust the dough with flour, put it in a large, lightly oiled bowl, cover with a damp towel and let rise to double in bulk. This is a fairly fast rise and needs a warm environment, around 80 degrees, for one to three hours, usually about two.
3. Flour your hands and gently rework the dough to break up air bubbles. Pinch off an egg-shaped piece of the dough and reserve as the starter for subsequent adventures. Line a colander with a generously floured towel, and secure it around the colander's perimeter with a rubber band. Set the dough on the towel and let rise almost as far as it did on the first rise.
4. Preheat the oven to 450 degrees. Heat the base of the bread cloche.
5. When the dough is ready, sprinkle the cloche base liberally with cornmeal. Then, grasping the towel, pick up the loaf, and roll it gently onto the cloche base so that the round part faces up. Slash the surface in three places with a sharp knife or single-edged razor blade. Place in oven, cover with cloche top, and bake for 15 minutes.
6. Reduce heat to 400 degrees and bake another 20 minutes. Then remove the cloche top to brown the crust for about 10 minutes. The loaf is done if it sounds hollow when tapped on the bottom. After it cools, store in a closed paper bag.

Yield: One crusty loaf

ized, existential encounter with their coo
ing essence and with the full potential
their ingredients.

He is right. Sure, the artisanal eleme
is always present in every kitchen. Ev
the simplest recipe can be distorted by
cook without the spark that Lorca call
duende. I recently gave such a recipe to
professional test cook, who transformed
carefully literal blueprint for a drama
dish into a totally conventional, almo
tasteless waste of food. Part of the pro
lem was that the test cook had never tast
the dish, but most of the problem was th
she had no palate, only a technical grasp
cooking, and even so, she had never rea
understood how to sauté chicken so tha
actually browned and improved in taste

I like to think, however, that this wom
could be taught, in a class or even by t
printed word, to overcome her lack of fla
The same thing ought to be true of baki
an artisanal loaf. The variables are m
tiple, including, especially, fluctuations
weather. On the technical level, it do
take a while for a novice bread baker to g
the feel of a properly kneaded doug
whose lively elasticity translates into go
bread. Starters do go into tailspins a
cease to perform.

But after watching the artisan I live w
turn out loaf after loaf of prime sourdou
bread, I am persuaded that it is possible
bake well and reliably most of the tim
Ironically, Thorne himself has made t
easier to achieve, with the recommend
tion of an industrial product meant
standard home ovens (the baking cloch
and with the discovery of a fundamen
law for writing effective bread recipes.
states: "All three loaves...are made f
lowing what is, essentially, the sa
method. It begins with 1¼ cups of wate

In other words, if you have a worki
starter and you know what properly ris
bread dough feels like (and you have
have a pretty good idea of that to ba
bread at all), then the problem of writin
reliably quantified recipe comes down
one thing—setting the amount of wa
The rest is a straightforward process t
can be written down in clear terms anyo
can follow to the letter. Even thou
Thorne insists that his directions for ba
ing an artisanal loaf are "not a recipe,"
has come up with an extremely practi
rule of thumb that gives him even m
analytical control than a normal recipe.

*Raymond Sokolov is a writer whose sp
cial interests are the history and prepa
tion of food.*

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With eyes wide open and ears cocked, female impala take their turn at a water hole on the Okavango Delta in Botswana. On high alert, each drinks her fill in minutes to minimize the chances of falling prey to lions, leopards, or wild dogs that may be lurking nearby.

Impala can go several days without water if they can graze on green grasses; but during the dry season, when they browse on leaves, seedpods, and shoots, they must quench their thirst every morning and thus are rarely found more than a few miles from water. Then, and especially in time of drought, the Okavango River provides a vast oasis. Never reaching the coast, its waters end in an inland depression, then branch out into shallow, meandering waterways to form a delta. When these wetlands shrink markedly after a prolonged drought, the water holes that remain are vital to the survival of antelope and other wildlife.

During lean periods, adult male impala are essentially independent of the herd of females and young; the benefits of maintaining harems are outweighed by the high energy costs of herding females and chasing away rival males.—*R. A.*



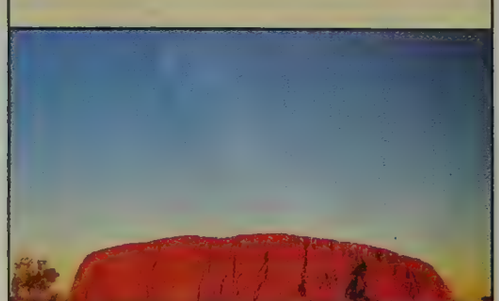
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AUTHORS



Carol A. Kearns (page 30) is currently an assistant professor of biology at West Virginia Wesleyan College in Buckhannon, West Virginia. Her interest in fly pollination began while she was a graduate student working at the Rocky Mountain Biological Laboratory, in Gothic, Colorado. After completing her Ph.D. in 1990, she became assistant director of the University of Colorado's Mountain Research Station. She plans to continue her work on the reproductive biology of montane plants, focusing on the differences in inbreeding levels among plant populations visited by different pollinators. **David W. Inouye**, past director of the Mountain Research Station and now associate professor in the Department of Zoology at the University of Maryland, was Kearns's disser-



David C. Smith and **Josh Van Buskirk** (page 38) are shown measuring tadpoles at the chorus frog study site, on a rocky shore of Lake Superior. Smith (right), an ecologist at Williams College, majored in biology at Yale, then earned his doctorate at the University of Michigan in 1977. During the 1970s he did fieldwork on lizards in southeastern Arizona, seeking the factors that control survival during juvenile and adult phases. On a vacation in Isle Royale, Michigan, he saw rock pools full of tadpoles and thought the area would be a great place to study frogs. Josh Van Buskirk, currently at the New York Botanical Garden Institute of Ecosystem Studies at Millbrook, New York, majored in biology at Williams College, where he studied with Smith. Van Buskirk earned his Ph.D. in zoology at Duke University in 1990 for research on the population dynamics dragonflies. He has also investigated turtle ecology, how amphibians prot themselves against predators, and spread of Lyme disease through bird mammal populations. He became int ested in the chorus frogs of Isle Roy when David Smith hired him to be a fi assistant there in 1983; they have cont ued to collaborate for eight years. In th off time, Smith and Van Buskirk share terests in hiking, birding, and white-wa kayaking. For further reading they reco mend *The Encyclopedia of Reptiles a Amphibians,* by Tim Halliday and Kr Adler (New York: Facts on File, 198 and Michael J. Ryan's *The Tungara Fr A Study in Sexual Selection and Comm nication* (Chicago: University of Chica Press, 1985).



tation adviser. His interest in pollination biology is longstanding, but he first took a serious look at flies in 1984, while on sabbatical in the Snowy Mountains of Australia. Inouye's current research includes several long-term projects on wildflowers and their pollinators at the Rocky Mountain Biological Laboratory and work with a graduate student on reproduction in the glacier lily. For more on pollination, the authors suggest *The Sex Lives of Flowers,* by B. Meeuse and S. Morris (New York: Facts on File, 1984), and *Insects and Flowers: The Biology of a Partnership,* by F. G. Barth (Princeton: Princeton University Press, 1985). Kearns and Inouye's book, *Technique for Pollination Biology,* will be published this spring by the University Press, University of Colorado.

Since getting his Ph.D. in zoology from e University of California at Berkeley in 965, **Thomas T. Struhsaker** (page 42) as lived mostly in Africa, where he stud- s rain forest ecology and monkeys. In 975, coauthor **Lysa Leland**, who had ent the previous year with zoologists oger and Katy Payne in Patagonia re-



earching whales, joined Struhsaker in ganda's Kibale Forest as a Wildlife Con- rvation International Fellow of the New ork Zoological Society. "I was born the ear of the Monkey, and a big imprint of y early childhood in Massachusetts was eding grapes to a neighbor's pet monkey at bit kids," says Leland. "No doubt I as destined to live with them in the ild." Struhsaker likewise succumbed arly to a fascination with monkeys. Vhile observing vervets in Amboseli ark, Kenya, more than thirty years ago, he discovered they had specific alarm calls for different predators, among them crowned eagles. Struhsaker plans to continue primate field studies and to supervise graduate students in Zanzibar and Kenya, as well as in Kibale. Leland is working on an official field guide commemorating Kibale's new status as Uganda's first forest park. For additional reading, Struhsaker and Leland recommend *Primates in Nature,* by A. F. Richards (New York: W. H. Freeman and Co., 1985), and *The Birds of Africa,* vol. 1, by L. H. Brown, E. K. Urban, and K. Newman (New York: Academic Press, 1982).



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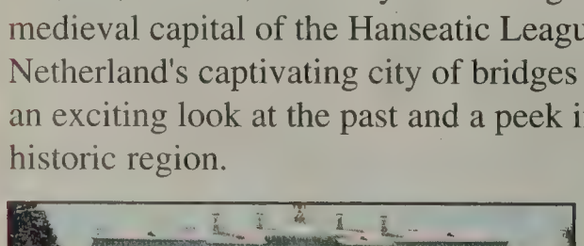
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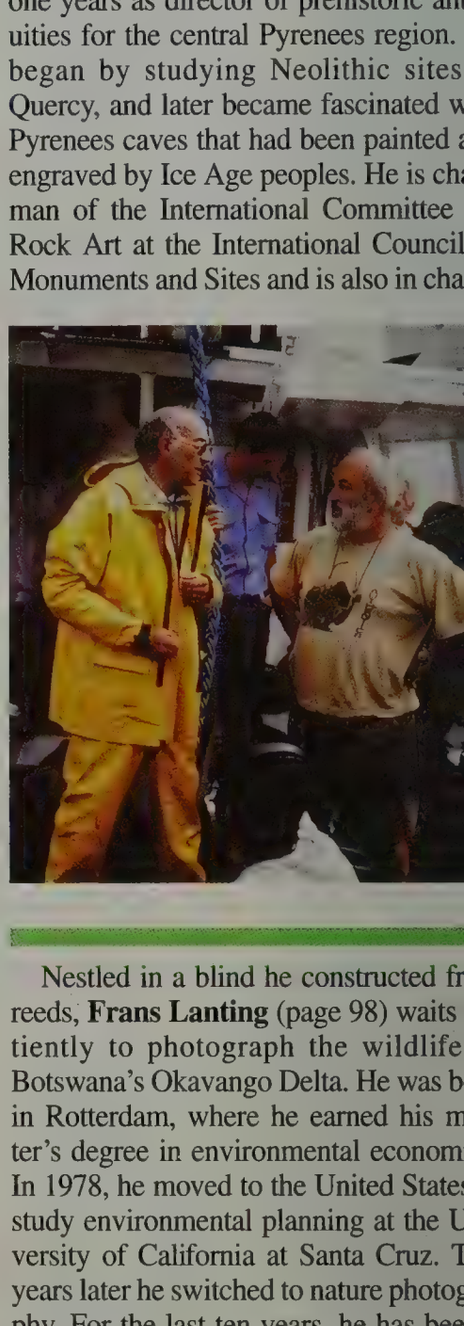


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Standing on the deck of the *Arch naute,* a ship specially fitted for underw ter archeology, **Jean Clottes** (left) spea to **Jean Courtin** during the June 1992 ries of dives to the Cosquer cave, n Marseille in the South of France (page 6 Jean Clottes, who earned his Ph.D. at University of Toulouse, served for twen one years as director of prehistoric ant uities for the central Pyrenees region. began by studying Neolithic sites Quercy, and later became fascinated w Pyrenees caves that had been painted a engraved by Ice Age peoples. He is cha man of the International Committee Rock Art at the International Council Monuments and Sites and is also in cha



Nestled in a blind he constructed fr reeds, **Frans Lanting** (page 98) waits tiently to photograph the wildlife Botswana's Okavango Delta. He was b in Rotterdam, where he earned his m ter's degree in environmental economi In 1978, he moved to the United States study environmental planning at the U versity of California at Santa Cruz. T years later he switched to nature photog phy. For the last ten years, he has bee professional nomad, sometimes spend more days on airplanes than at his ho near Monterey Bay. He has documen the monarch butterfly migration to M ico, lived for months with albatrosses small islands in the Pacific, summe with Kwakiutl Indian artists alo Canada's west coast, and camped amo giant tortoises inside a volcano in Galápagos Islands. In addition to frequ assignments for *National Geograph* Lanting has several books to his credit is currently working on three more. La ing used a Nikon camera and a 300

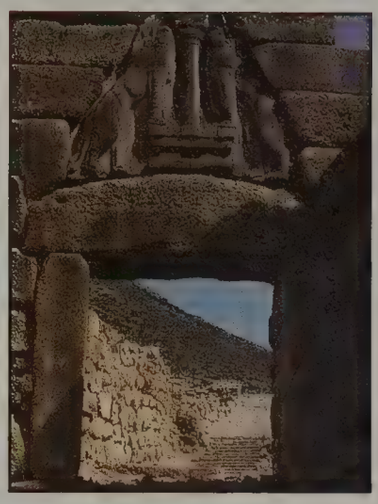
prehistoric rock art studies at the French nistry of Culture. His research focuses the dating of cave art and its archeolog- l context. Born in St. Tropez, France, in 36, Jean Courtin developed a passion prehistory after a boyhood discovery flint tools in his family's vineyards. As a duate student, he specialized in the Ne- thic and Bronze Age cultures of ovence and led many on-site excava- ns. Between 1962 and 1967, he worked ensively in the northern region of the public of Chad, where he discovered ndreds of prehistoric sites. For more n twenty years, he has also led the ex- vation of the Fontbrégoua cave at lernes—an important site that was in- bited between 12,000 and 4,000 years o. An accomplished scuba diver (he be- me codirector of the Undersea Research oup at Marseille) and one of the ance's outstanding underwater archeolo- sts, Courtin was a natural choice to con- ct the exploration and study of the Cos- er cave. He is now a director at the tional Center for Scientific Research, as ell as director of prehistoric antiquities Provence–Côte d'Azur. For further ading, Clottes and Courtin recommend *leolithic Cave Art,* by P. Ucko and A. senfeld (London: World University Li- ary, 1967), and *Images of the Ice Age,* by Bahn and J. Vertut (London: Windward, 88 and New York: Facts on File, 1989).

s to photograph this month's "Natural oment," a row of impala drinking from a ter hole on the Okavango Delta. The oto will appear in his upcoming book *kavango: Africa's Last Eden,* to be pub- hed this fall.



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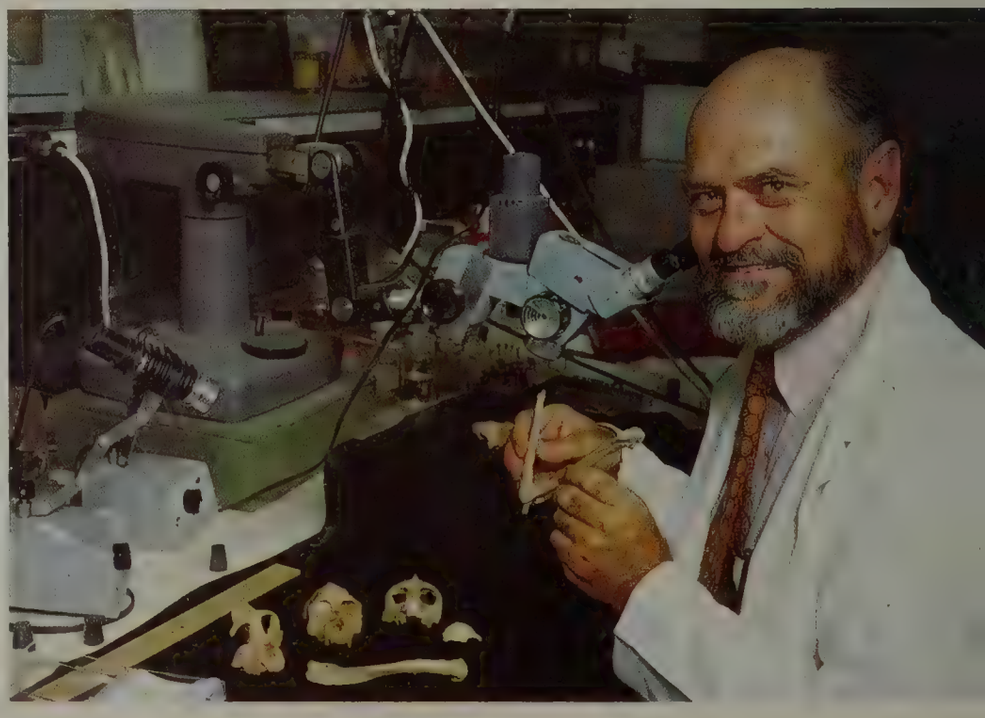
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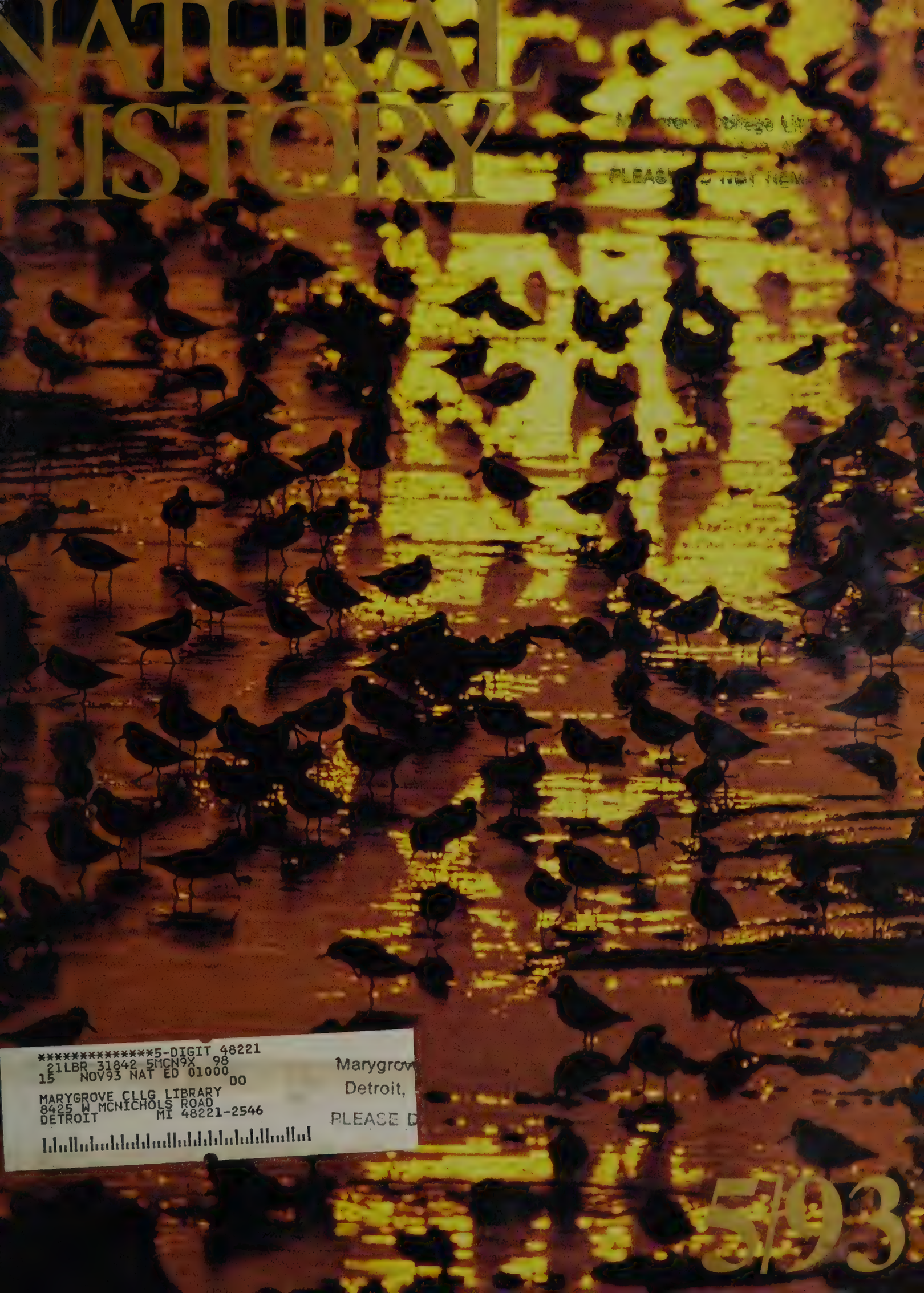
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Following the discovery of the Icem by Alpine tourists in the fall of 1991 (pa 60), osteologist **Torstein Sjøvold** (le joined the team investigating the medi and natural science aspects of the fi Born in Norway, he has carried out sev seasons of archeological survey and ex vation at high mountain sites in that co try. Interested in the development and plication of statistical methods, he has a been exploring the population genetics skeletal collections. Sjøvold received doctorate from the University of Sto holm, Sweden, where he now heads Osteological Research Laboratory. For ditional reading he recommends the ill trated book to be issued this fall by Kon Spindler and the research teams at University of Innsbruck. It is tentativ entitled *The Man in the Ice: The 5,0 year-old Glacier Mummy from Hausl joch in the Ötztaler Alps.* A compreh sive sourcebook is a collection of pap mostly in German: *Der Mann im E Band 1,* edited by Frank Höpfel, Wer Platzer, and Konrad Spindler (Innsbru University of Innsbruck, 1992).

While attending the 1933 Chicago World's Fair at the age of three, **Elwyn Simons** (page 58) was frightened by an animated dinosaur. This, he says, launched his life-long interest in fossils. As a graduate student rummaging through the collections of the American Museum of Natural History, he discovered some undescribed monkey fossils from Egypt's Fayum badlands. Since then he has mounted numerous expeditions to that region in search of fossils documenting the early stages in line leading to higher primates—m keys, apes, and humans. Simons is a fascinated by more recent ancestors, h ing written a book and several unp lished manuscripts on his family gene ogy. The James B. Duke Professor Biological Anthropology and Anatomy Duke University in North Carolina, mons is also the scientific director of Duke Primate Center.





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NATURAL HISTORY

Vol. 102, No. 5, May 1993



COVER: *During their spring migration, birds feed on the New Jersey shore of Delaware Bay at sundown. Story on page 8. Photograph by Michael Baytoff.*

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To build their nests, many birds recycle the webs of spiders.



Paleolithic hand image, Pech-Merle, France

HOW DID HUMANS GET THAT WAY?

The second of two special sections about steps in our long, punctuated path to becoming humans, presented in conjunction with the opening of the new Hall of Human Biology and Evolution at the American Museum.

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LETTERS

WINNIE VERSUS OBAYSCH

I read with interest Nina J. Root's article, "Victorian England's Hippomania" (February 1993). Everything went well until I read the last paragraph, which states, "With the exception of Jumbo, no other captive animal's life had been so thoroughly recorded and popularized as Obaysch's."

I beg to differ. Surely Winnie the Bear of the London Zoo, made world famous by A. A. Milne in his book *Winnie the Pooh,* has been as well recorded and popularized.

Winnie was a black bear cub taken to England by a veterinarian in the Canadian Army during World War I. The bear cub was picked up somewhere near Winnipeg, hence the name "Winnie," taken by train across Canada to Halifax, then by steamer to England. As the bear could not be taken to the war front, it was donated to the London Zoo.

ROBIN LEECH
Edmonton, Alberta
Canada

The bear cub known as Winnie arrived at the London Zoo in 1914 and was a favorite of zoogoers for twenty years. A statue of the bear was erected in the zoo in 1981.—*Ed.*

TABLOID SCIENCE?

In "On the Solar System's Edge" (February 1993), Gail S. Cleere writes about the discovery of a new "miniplanet" in our solar system: "Jewitt and Luu report that the reddish color of the new object is consistent with a surface composition rich in organic material."

How do they know? So far, organic material has been discovered only on our good old Earth, which is not reddish any more. This revelation sounds less credible than the news that Elvis is alive and well (which I spotted some time ago in my supermarket's tabloid).

JANUSZ Z. BYCZKOWSKI
Dayton, Ohio

According to Jane Luu, one of the miniplanet's discoverer's, the reddish color can be explained in a number of ways, but t most likely is a thin coating of organic m terial. Here's why: First, the 125-mi wide body is assumed to be composed frozen water, ammonia, methane, and c bon dioxide, ices that would have co lesced in small bodies at the edge of t solar system soon after its formation. number of researchers, including C Sagan, have bombarded such ice wi high-energy particles, similar to the co mic rays that pervade space. They fou that when cosmic rays strike the ice, h drogen atoms are knocked loose, freei carbon atoms to bond with one another, well as with such other elements as sulf The result is a dark, reddish residue of o ganic molecules. Organic molecules c have nonorganic origins. The universe filled with them.—*Ed.*

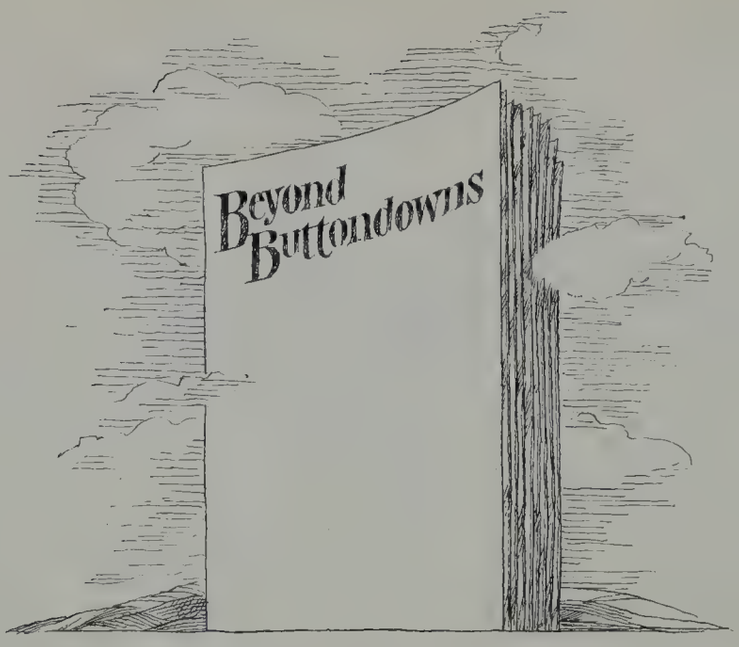
INORDINATE FONDNESSES

In Stephen Jay Gould's essay "A Sp cial Fondness for Beetles" (January 199 he examined how a famous quip was pr mulgated in the annals of biological h tory as that of British biologist J. B. Haldane, although it does not appear in h writings. Gould skillfully questioned t various sources and motives that immo talized Haldane's clever one-liner about apparent predisposition of the Creato "An inordinate fondness for beetles."

I recently encountered a similar cr ational inference attributed to Abraha Lincoln: "God must be fond of ordina people, or He wouldn't have made many of them" (in *We Live with Our Ey Open,* 1949). As Lincoln died thirty yea before Haldane was born, it makes o wonder how original even to Lincoln w such a slant on the Creator's fondness.

GEOFFREY SIMBE
Ionia, Michig

ERRATUM: The editorial department r grets that in converting from Centigrade Fahrenheit in "The Underside of Winte (February 1993), it neglected to drop minus sign on page 53. Subnivean tempe atures in the Far North may be as low 23° F, not –23° F.



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Shorebird Squeeze

When beaches become playgrounds by day, some birds find themselves in the dark

by Joanna Burger

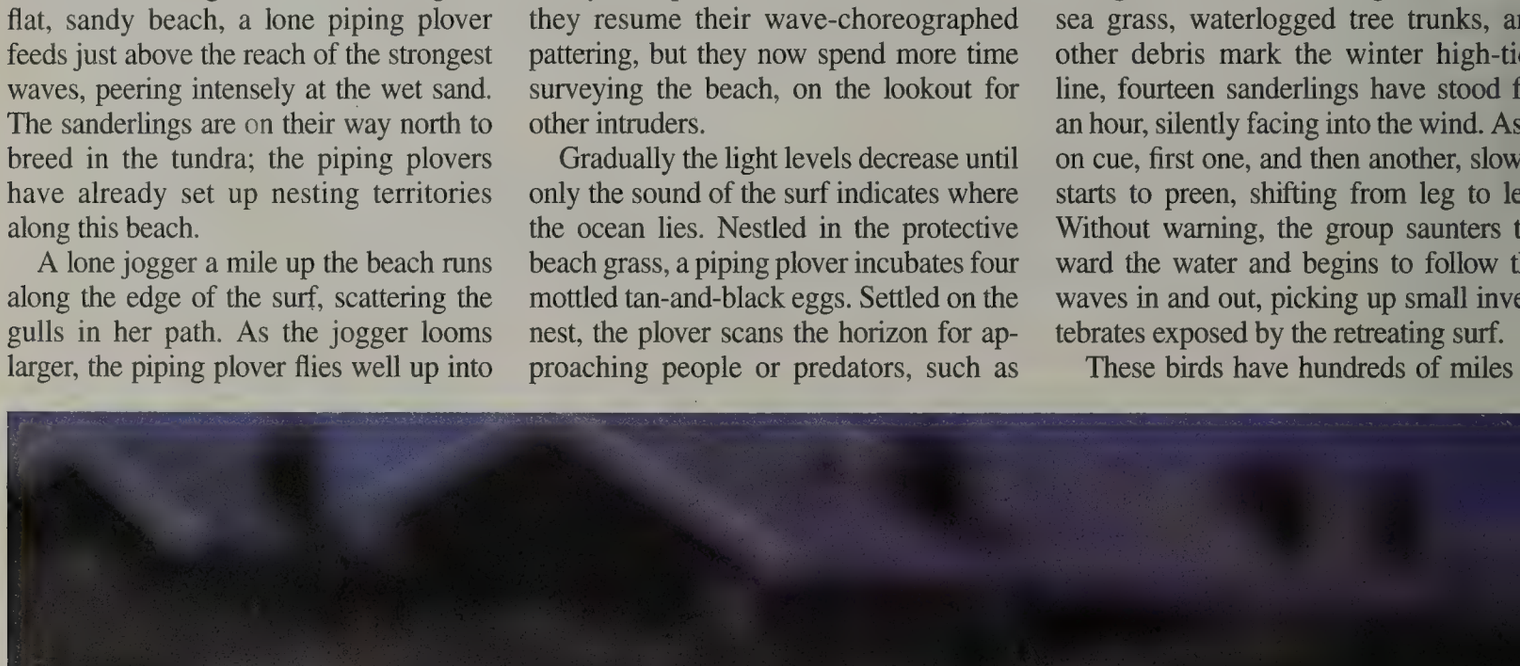
At dusk on a day in early May, sanderlings foraging in a small flock along the New Jersey shore expertly dodge the waves of a falling tide. Farther along the flat, sandy beach, a lone piping plover feeds just above the reach of the strongest waves, peering intensely at the wet sand. The sanderlings are on their way north to breed in the tundra; the piping plovers have already set up nesting territories along this beach.

A lone jogger a mile up the beach runs along the edge of the surf, scattering the gulls in her path. As the jogger looms larger, the piping plover flies well up into the dunes. The sanderlings watch the jogger, and only when she is thirty feet away do they wheel into the air, to land a hundred yards up the beach behind her. There, they resume their wave-choreographed pattering, but they now spend more time surveying the beach, on the lookout for other intruders.

Gradually the light levels decrease until only the sound of the surf indicates where the ocean lies. Nestled in the protective beach grass, a piping plover incubates four mottled tan-and-black eggs. Settled on the nest, the plover scans the horizon for approaching people or predators, such as hawks or foxes, listening intently f sounds that herald danger.

Pitch black gives way to soft moonligh Along the berm, where tangled masses sea grass, waterlogged tree trunks, a other debris mark the winter high-ti line, fourteen sanderlings have stood f an hour, silently facing into the wind. As on cue, first one, and then another, slow starts to preen, shifting from leg to le Without warning, the group saunters t ward the water and begins to follow t waves in and out, picking up small inve tebrates exposed by the retreating surf.

These birds have hundreds of miles



A piping plover (far right) nesting on the New Jersey shore relies on shell-strewn sand for camouflage.
Photographs by Michael Baytoff


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Tens of thousands of migrating and nesting shorebirds fatten on the beaches of Delaware Bay in spring.

migrate before they reach their northern breeding grounds in the Canadian Arctic, and the marine invertebrates they find on the Jersey shore will help fuel their journey. When the birds arrive on the tundra, it may still be snow covered, and insects and other foods may be scarce. Female sanderlings that still have sufficient fat reserves will get a head start in egg laying and incubation. Time is critical if a bird is to successfully raise its brood before the short arctic summer gives way to autumn. Foraging along coastal beaches during migration is therefore vital, and it is most productive during low tides when the sands of the intertidal zone, which harbor invertebrates, are exposed. On some days only one low tide occurs during the daylight hours, restricting both the migrants' time to feed and the abundance of the fare.

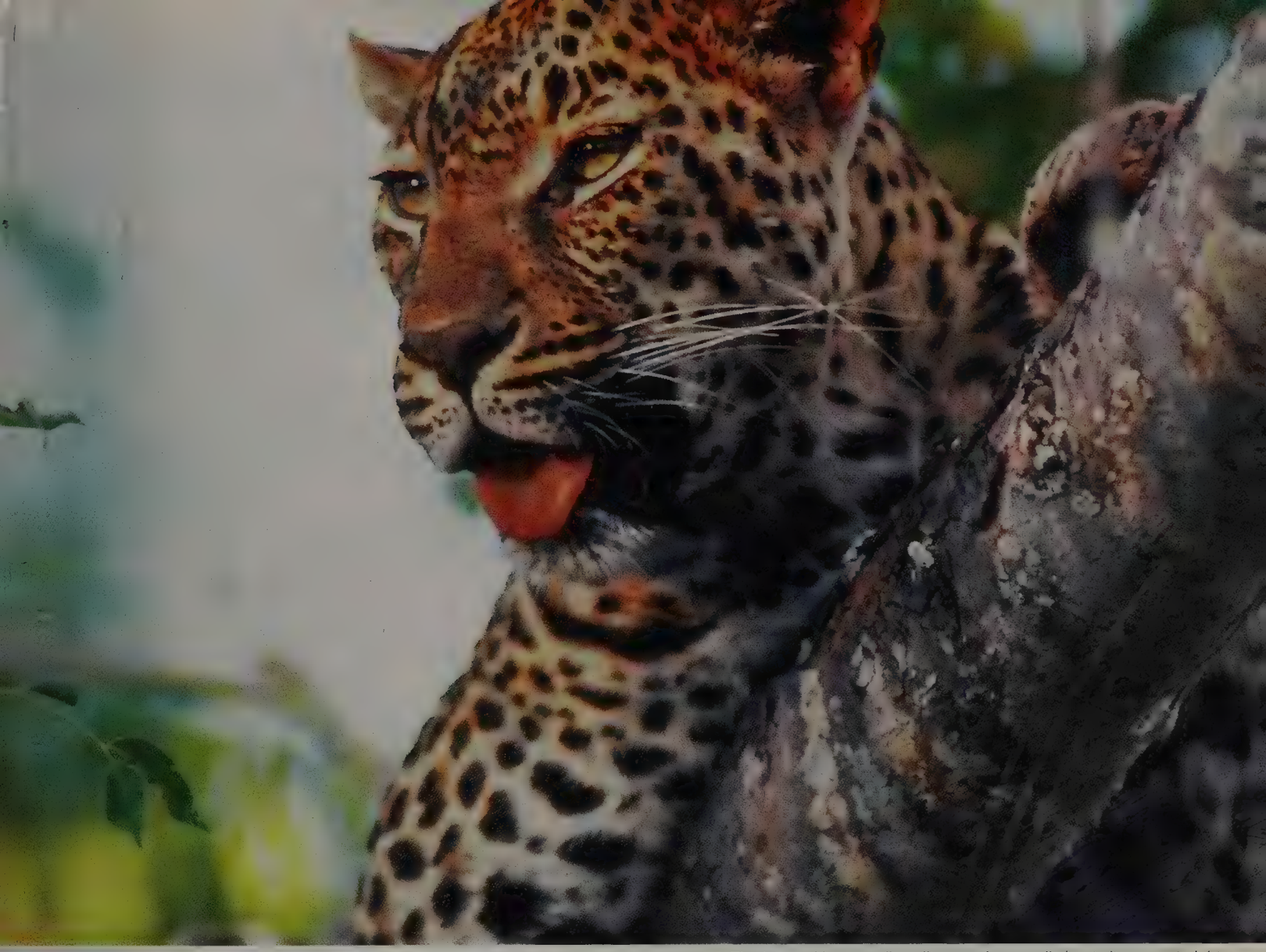
Coastal birds have evolved to deal with the changing tides, to learn when and where they can forage, and to maximize the food they can find in this ever-changing environment. For many thousands of years, uninterrupted by people, they fattened on these Atlantic beaches. Only in the last few decades have beaches undergone extensive development. And with development have come beachgoers, vying for the same habitat as migrant shorebirds, such as sanderlings, and nesting birds, such as skimmers, gulls, terns, and piping plovers.

Some beach nesters—skimmers, gulls, and terns, for example—can cope with people better than other nesters can. These species nest in noisy colonies and will mob and attack two- and four-legged prowlers alike. A tern that spots an interloper near the colony cries out, alerting its neighbors, and is apt to divebomb the intruder. But birds such as piping plovers, oystercatchers, and willets rely mainly on camouflage, and their nests are situated far from other birds that might give early warning of danger. Their habit of nesting solitarily also makes it difficult for conservationists to set aside zones to protect many of their nests simultaneously.

The nests and eggs of these ground-nesting birds are unwittingly stepped on and driven over. But another, less obvious threat exists: The precipitous decline of many beach-nesting species may be partly a result of competition with humans for space along the wave front, where the birds' food is concentrated. For eleven years, Mike Gochfeld, a professor of environmental medicine at the Robert Wood Johnson Medical School in Piscataway, New Jersey, and I have examined the interactions of people and shorebirds. We wanted to know if birds had any special strategies that allow them to coexist wit people, to find enough food to fuel the migration, and to raise healthy young.

Before we began our study, we knew that shorebirds occasionally feed at nigh during the winter, when days are shor And we had repeatedly observed tha sanderlings forage on moonlit nights i spring, suggesting that they and othe shorebirds regularly do so during migra tion, when food is particularly critical. W wanted to find out whether shorebirds fee nocturnally throughout the year, even o moonless nights, and whether this behav ior might help them cope with increasin human disturbance during daylight hour We have followed shorebirds day an night, on both temperate and tropica beaches. In the late 1980s, we were joine by Kevin Staine, a graduate student a Rutgers University, who was particularl interested in piping plovers.

In April, when the ocean winds are sti cold and before any migrant or reside shorebirds arrive on the Jersey shore, w lay out transects along several beache We choose some beaches that are use heavily by people, and others, such as Li tle Beach Island, that are wilderness area Gradually, sanderlings, knots, pipin plovers, and other shorebirds fly in fro the south. Piping plovers leave the flock



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and spread out along the beaches to establish territories and find mates.

We walk the beaches during the day with our binoculars and notebooks, recording which bird is feeding and where. Even early in the season, however, scattered beachgoers lie on towels, surrounded by chairs, umbrellas, coolers, and other paraphernalia indicative of sun worship. On a typical day, the cool breezes give way to warm sunshine, and the ocean is calm. Ahead, a lone piping plover flutters along the sand, its wings outstretched, its body tilting to one side as if its wing were broken. Slowly we follow, and it flops on, only a few feet ahead of us. It continues for twenty feet, tilting, apparently painfully, from side to side. Just as we catch up, it becomes airborne and circles far over the dunes. We must have passed the bird's nest, for piping plovers give this distraction display to draw predators and people away from their eggs, and later in the season, their chicks.

At dark we bring out our "sniperscope," an image-intensifying telescope designed to amplify the tiniest sliver of light into a visible image on a round, two and one-half inch screen. The pale green image shows barren sand and gentle waves. Even when our eyes can detect nothing, shapes materialize on the screen. We walk slowly along our transect, searching the sand.

On the screen, a small, fuzzy, green ball seems to roll up and down in the surf. As we get closer, we see that the ball has legs, and the image resolves into a piping plover. It probes gently in the surf, finding food by touch rather than by sight, as it does during the day. Using stopwatches, we record how much time the plover devotes to foraging and how often it is vigilant or engaged in other activities.

At the end of our transect, we find a small flock of sanderlings. Each new wave draws more invertebrates toward the sand surface. Maintaining contact with low calls, the birds stay much closer together than they do during the day; the flush of food assures that no individual is crowded out. They move slowly along the beach, almost disappearing in our green image. We move back and sit quietly, waiting to begin our next census.

Suddenly a loud rumbling breaks the spell. The sanderlings must also hear the sound, for they stop foraging and gaze into the darkness. A jeep appears on our screen, careering above the tide, its headlights off to avoid detection by beach patrols. Just in time, the sanderlings scatter flying in all directions. Minutes later they regroup on the berm, anxiously preening their feathers and peering about. Nearly an hour elapses before they slowly make their way back to the beach. But the tide has changed and is beginning to rise. Foraging will not be as good as it had been on the falling tide.

We often concentrate our observations on piping plovers because they are endangered and their numbers have dropped drastically. Fewer than a thousand pairs now nest along the Atlantic coast. We want to find out how important nocturnal foraging is to them so we can ascertain the importance of restricting nighttime human use of beaches to specific places or times.

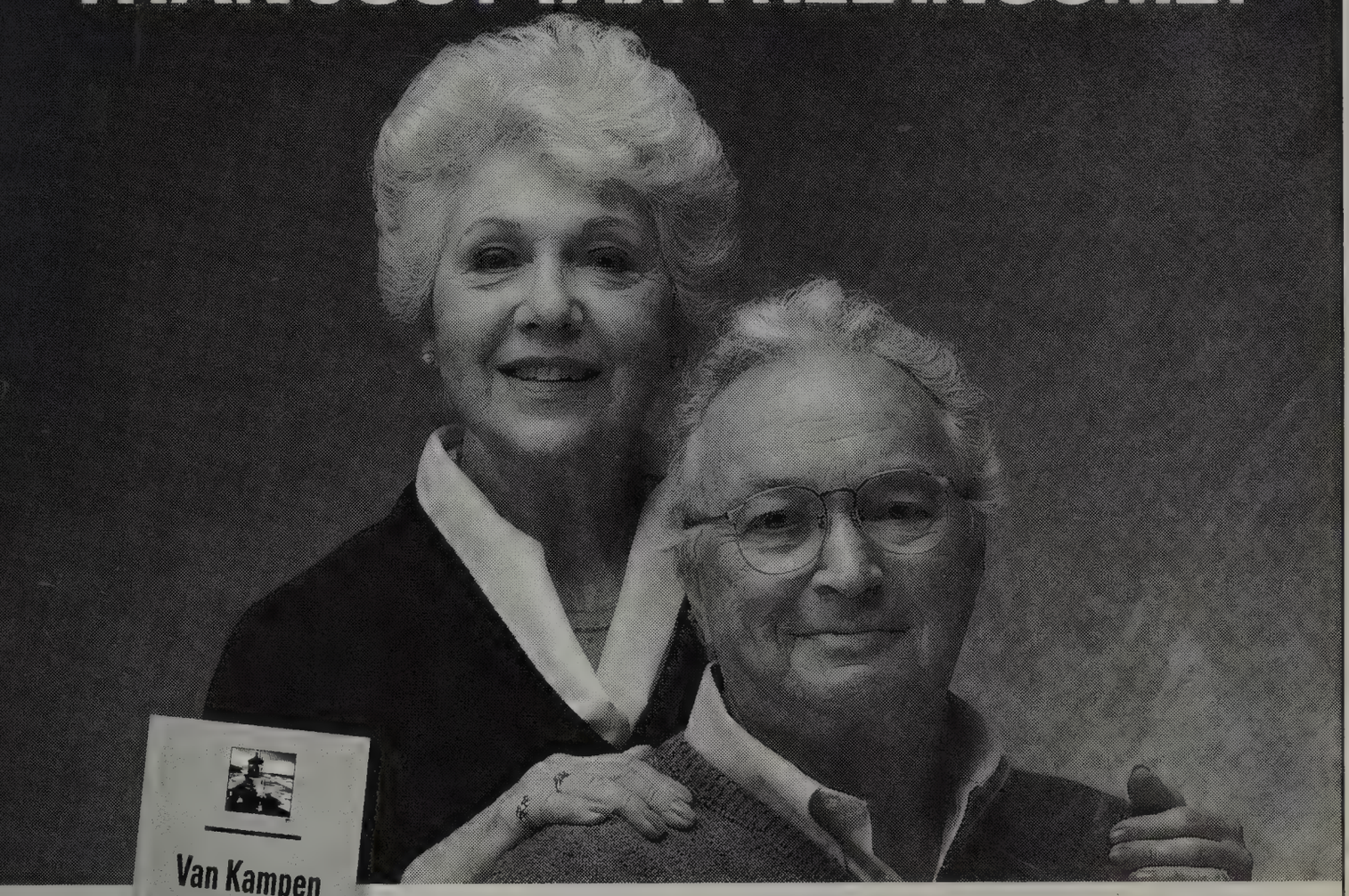
Over the months and years, a pattern has emerged. During the day, piping plovers feed along the surf. On beaches such as Brigantine, Holgate, Corson's Inlet, and Whale Beach, we usually find one or two plovers feeding every hundred yards. When foraging placidly, they devote nearly 70 percent of the time to actually feeding and the rest to watching for people or predators, displaying to mates or neighbors, or racing to a new foraging site. They peck at the wet sand in search of

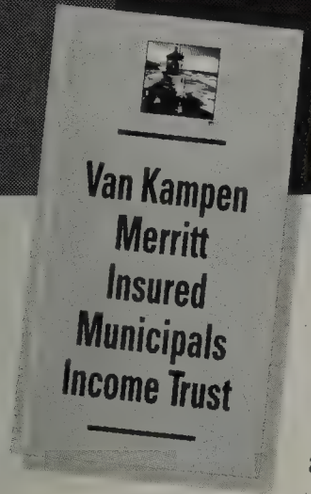


The nests of colonial birds, such as terns, are more easily protected from beach traffic than are those of solitarily nesters, such as piping plovers.

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food an average of forty times per minute.

When Brigantine Beach and Corson's Inlet become crowded and the plovers are regularly disturbed by people during the day, they can feed less than 40 percent of the time, and their pecking rate is cut to a third what it is on beaches with few people. The birds then spend most of the time on the alert, dashing to new foraging sites, or avoiding people by retreating up the beach to the berm, where they remain alert for minutes after the disturbance has passed.

At night, beach intrusions are somewhat less disruptive, reducing the birds' feeding time by less than a third. This difference occurs because night disturbances, such as the passage of a jeep or a jogger, are short. Prolonged daytime interruptions sometimes force the birds to seek other beaches or resort to feeding on mud flats or salt marshes. We found that the more people used beaches by day, the more birds foraged at night. One of the most important variables directly affecting foraging piping plovers during both daytime and nighttime is the number of people within fifty yards of them.

We have found that shorebirds, including piping plovers, forage on most nights, but their numbers vary depending on the stage of their breeding cycle, on the tidal cycle, and on how many migrants, such as sanderlings, are around. More plovers forage at night during the territory acquisition and brood-rearing stages than during incubation. This makes sense, because at least one member of each pair must incubate the eggs. Thus only half the resident population can be off foraging at one time. Once the chicks hatch, parents devote more time to vigilance and to protecting the young. This takes time away from the adults' own foraging and may contribute to their low survival rate during the southward migration in fall. As the chicks get older, they feed with their parents along the waves nearly every night. Over the years of our study, we found that both members of every pair of plovers fed on some nights. Given the low probability of finding birds along an expanse of open beach within the range of our night-vision scopes, this finding amazed us.

Over the years, our observations have indicated that the problem of competition for quiet space is not just a summertime phenomenon. As shorebirds migrate to southern beaches during the winter, so do millions of Americans. In southern Florida the sandy beaches are often narrow, not only because of normal coastal processes and hurricanes but also because beachfront development has eliminated the natural shrubs and dunes that protect beaches from erosion. Often only a narrow stretch of beach is left between tall hotels and t surf. In Florida, small flocks of sanderlir and other shorebirds allow people to a proach more closely than they do on c northern beaches. Such tolerance is d tated by the sheer numbers of beachgoe In the winter of 1986, Mike Gochfeld a I began tracking the populations of sand lings and people along Del Ray Beach, b tween Palm Beach and Fort Lauderda While the number of sanderlings in t winter has remained the same, the numb of humans within a hundred yards of f aging sanderlings rose by a factor of th teen. Over just a five-year period, sand ling daytime foraging rates, like those plovers, were cut nearly in half. In ad tion, the birds' time spent on the alert i creased fifteenfold, and actively foragi sanderlings had to run or fly from a proaching people eight times as often.

Sanderlings and other shorebirds co pensate for these daytime disruptions continuing to forage at night. Nowada we see them foraging after dark in any c serted place they can find. Although t pecking rate decreases at night (when th cannot use visual cues to find prey), t time they can forage increases.

In 1986 when we began our shorebi studies in Florida, few people used t beaches at night. However, as human po ulations increased, many individua found jogging on the crowded beach during the day unappealing, and son have shifted their exercise routines to du and darkness. By 1991 our nighttime o servations were nearly always interrupt by at least one jogger. Given the sho range of our sniperscope and the difficul of hearing joggers over the pounding su the appearance of a jogger is sudden a jarring. We and the shorebirds scatter high ground to await the jogger's passa and the return to quiet.

Summer and winter I am struck by t continuing, increasing nighttime use of t beaches by shorebirds, gulls, and ter Under cover of darkness, the birds obta enough food to meet the stresses of ove wintering, migrating, and raising the broods. The increasing human use beaches at night, often motivated by t same desire to escape crowds, threatens put additional strains on shorebirds. Di enfranchised by day, they are now in da ger of also losing the night.



"...the hurricane is packing winds of 105 miles an hour, and landfall is expected about 7:30 tonight."

Joanna Burger is a professor of biolo and director of the graduate program ecology and evolution at Rutgers Unive sity, New Brunswick, New Jersey.

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Four Antelopes of the Apocalypse

Silently, they watch "to see how many we will bring to their sorry fate"

by Stephen Jay Gould

George Washington died on December 14, 1799, after scorning the classic advice of zealous guardians and staying out far too long on horseback in the winter's cold and snow. I have always felt sorry that America's old man missed the 1800s by less than three weeks (although I have no evidence that he cared about such artificial milestones). I also confess to a feeling of privilege and pleasure that most of us will live to witness something even rarer—the inception of a new millennium.

But Washington was not alone in missing this admittedly arbitrary transition by a hair. Half a world away, just east of Cape Town in South Africa, a Boer huntsman shot the very last blaauwbock, or blue antelope, thus completing the first extinction of a large-bodied mammalian species in historic times. (Perhaps the blue antelope just managed to sneak through, for some sources mention 1800 as the date of the death for the last buck, although most agree on a terminus in 1799.)

The heads of museum collections are called curators, from a Latin word (*cura*) with a range of meanings, from care to management to heartache—all appropriate at various times (as I should know, for I am, by title, curator of invertebrate paleontology at Harvard's Museum of Comparative Zoology). The job, although often sublime, can become quite sad when the objects in our charge are remnants of extinguished vigor—scraps, fragments, and artifacts of creatures that should be thriving but that have succumbed to human rapacity. Curators can become zealous in such lamentable situations, for we often



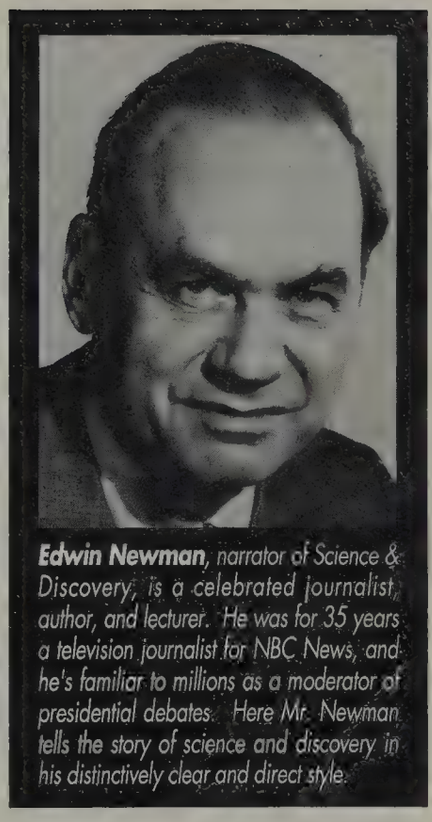
The blaauwbock, from a 1778 edition of Buffon's Histoire naturelle
Rijksmuseum van Natuurlijke Historie, Leiden

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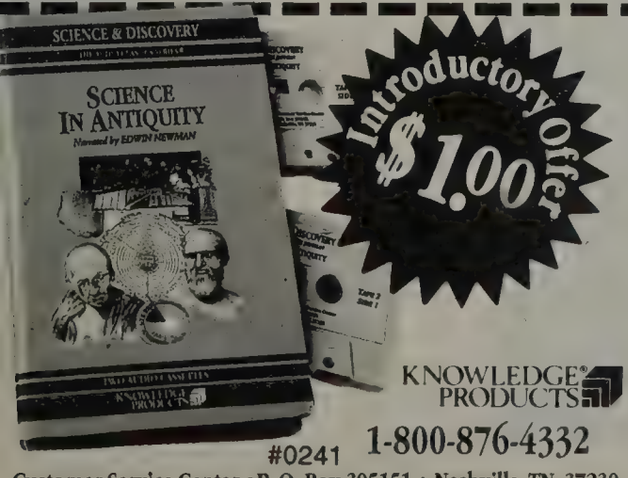
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hold the only palpable remnants of greatness that should still walk among us. We treasure a teen-ager's notebook in Amsterdam, as we preserve the balcony of a motel room in Memphis, for these are the legacies of Anne Frank and Martin Luther King, Jr. And we feel triumphant when we discover an object to materialize what had only been a rumor or a memory.

I once tracked down, thanks to the efforts of my colleague Paul Lombardo, the grade-school report card of Vivian Buck, who had died at age eight in the midst of the Great Depression. She had figured prominently in the infamous Supreme Court decision of 1927 that established the legality of forced sterilization. As a baby, she had been judged mentally retarded, the first fruit of a third generation of supposed imbeciles (her mother was subsequently sterilized as an outcome of the case). This humble scrap of paper from her last year of life proved that she had been a competent, if not brilliant, student—and that the diagnosis had been false. I exulted in the discovery, but then remembered that Vivian Buck should still be alive (for she died of a preventable disease of childhood poverty), enjoying an old age surrounded by a fecund and normal family. I rejoiced in the object (as a curator), but lamented that so little testimony should remain of a life cut short.

I recently witnessed another example of this principle during a tour through one of the world's finest zoological collections. In the Netherlands, Leiden is to Amsterdam as Boston is to New York—a considerably smaller but older city, lacking the bustling excitement of a commercial center, but rich beyond size in universities and other institutions of learning. Leiden's university, founded by William the Silent, prince of Orange, in 1575, is among Europe's best. Its natural history museum, formerly under royal patronage (as the Rijksmuseum van Natuurlijke Historie te Leiden), holds one of the world's great collections, particularly renowned for historical material dating to the dawn of modern zoology. The Netherlands, after all, enjoyed a brief period as the most powerful commercial and shipping nation on earth, and the Dutch East India Company spanned the world in a network of trade (and ultimately left a treasure of zoological specimens to the Leiden museum).

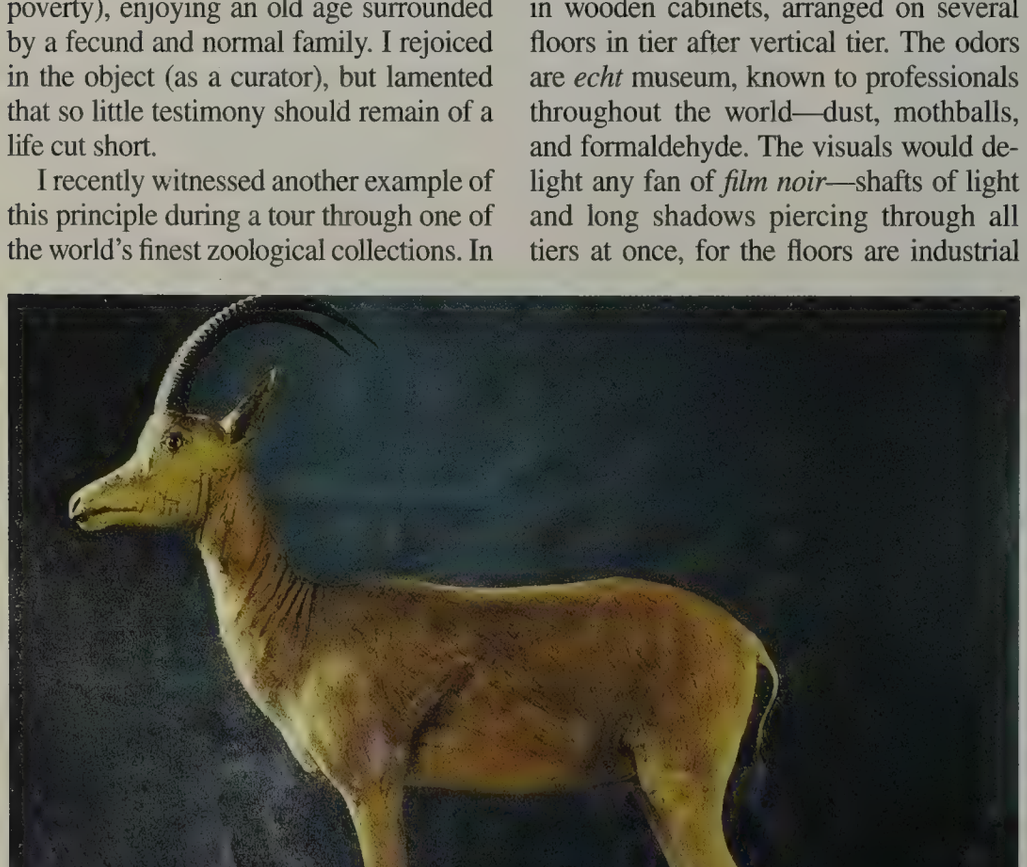
The Leiden collections are housed in a massive warehouse of a building, with a large, winding central staircase that served as the foundation for optical wizardry in some of M. C. Escher's most famous etchings (Escher's brother was a geologist stationed in Leiden). The specimens are held in wooden cabinets, arranged on several floors in tier after vertical tier. The odors are *echt* museum, known to professionals throughout the world—dust, mothballs, and formaldehyde. The visuals would delight any fan of *film noir*—shafts of light and long shadows piercing through all tiers at once, for the floors are industrial iron grating, not opaque concrete. Th theme of hidden mystery can only be en hanced by knowing that, for severa decades, the Leiden museum has pre sented no public exhibits (this will soo change)—and that these world-class col lections are therefore a private domain o zoologists in the know.

I recently enjoyed the privilege of a tou through this grand monument given by m colleagues Edmund Gittenberger, fellow researcher on mollusks, and Chri Smeenk, specialist in mammals. Smeenk led me up and down the tiers, past tigers elephants, and narwhals. But he was look ing for one specimen, the central jewel o this diadem, and could not locate it at firs (the hundreds of large wooden cabinet are effectively identical and often poorly labeled). He did not wish to ruin any sur prise by telling me what he was seeking so we ranged up and down tiers and aisle until we finally came to the right spot.

Smeenk opened the large door, reveal ing a slightly mangy (the mothballs de serve a noble purpose), badly faded mounted specimen of a medium-size African antelope with annulated horns in simple, backward-sweeping curve mark ing the genus *Hippotragus*. This genus in cludes two living species, the roan ante lope (*Hippotragus equinus*) of grassland from western Ethiopia to South Africa and the sable antelope (*H. niger*), with magnificent horns up to five feet in length of more wooded areas from Kenya to South Africa. The old specimen in Smeenk's cabinet did not look like either although I first thought that I might be looking at a young sable. My face did no therefore register the appropriate surprise and awe; I think that Smeenk was disap pointed.

I had forgotten (if I ever knew) that the genus *Hippotragus* had once, in historic times, included a third species—*H. leu cophaeus*, the blaauwbock (blue buck) o South Africa. Perhaps my ignorance will be forgiven, for no large mammal can match the blue antelope in obscurity Western science knew the living blaauw bock for less than half a century, for thi species was first mentioned by a travele in 1719, not formally described until 1766 and then exterminated in 1799. No skele tons exist, and only four mounted speci mens grace the collections of Europe Smeenk had shown me the best and mos famous of these four, a precious icon (and a mark of tragedy) in the fraternity of cu rators.

The first account of the blaauwbock



Blaauwbock specimen at the Leiden Museum
Rijksmuseum van Natuurlijke Historie, Leiden

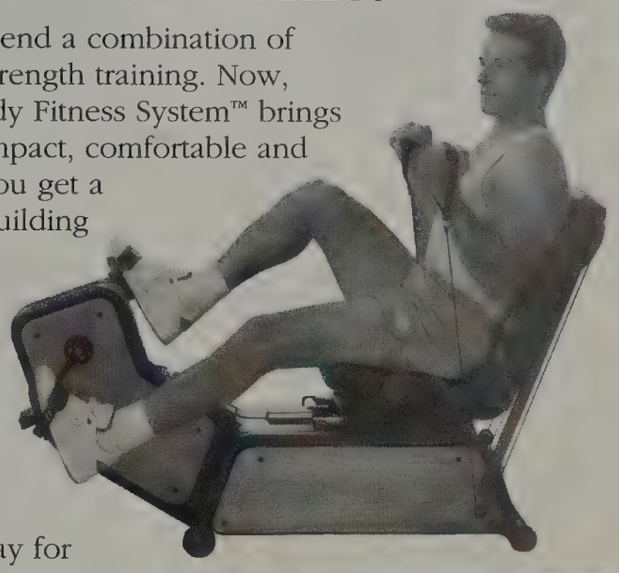
blished in 1719, already included some ts of impending doom. Peter Kolb, a rman businessman, worked in Cape wn and traveled extensively in South rica (which he called Hottentot-Hol-d) from 1705 to 1712. He noted that auwbock meat tasted "good enough... rather dry," and that the abundance of re succulent game spared the animal m much hunting for food. But Kolb atly praised the beauty of the hide, es-cially for the bluish tinge that had given animal its name. (Early reports are in-nsistent: some attribute the blue color to hair, others to the underlying skin; ne say that the color faded quickly after ath, while others disagree. None of the ur specimens in modern museums ows any extensive sign of blue color.) "I y truly say," Kolb writes, "that this ani-l appeared especially beautiful to my es because its blue hair is so much like color of the sky" (*Himmelblau,* or eaven blue," as he wrote in the original rman). Kolb therefore reports that the auwbock was hunted for its hide, not-, as a subsidiary benefit, that the subop-al meat could then be fed to the dogs. avelers and naturalists began to record blaauwbock's decline, virtually from day of its discovery. In 1774, C. P. unberg lamented its increasing rarity, ile H. Lichtenstein later reported that last-known animal had been shot in 99. Regret followed immediately, and ptain W. Harris, in his *Portrait of the me and Wild Animals of South Africa,* ote in 1840: "For a *Leucophaea,* I uld have willingly given a finger of my ht hand."

Only eight years after Linnaeus had dified the binomial system for naming mals (in the tenth edition of his *Sys-na Naturae* in 1758), the blaauwbock tered the formal rolls of science through work of a young German naturalist, ter Simon Pallas (1741–1811), who was ending several years in the Netherlands, n a virtual mecca for naturalists seeking best zoological specimens. Pallas ver finished the comprehensive treatise all mammals that he had begun with his scription of the blaauwbock and other mals in Dutch collections, for he re-ved an appointment as professor of nat-l history in Saint Petersburg, and soon t diverted to a range of other important jects, including the most significant hteenth-century treatise on strati-aphic geology and the first observations frozen mammoths. (Pallas's persona d brilliant career well represent the ecu-

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menicism of an admittedly small and ill-funded world of European science at the time. With relatively few places of employment and few sources of publication, and in the last years of Latin as a functioning common language, scientists could move across national boundaries and keep in touch.)

Linnaeus himself had given Pallas his imprimatur, describing him as "juvenem acutissimum in Entomologicis, ornithologicis et toto natura versatissimum" (a most intelligent youth, most competent in the study of entomology, ornithology, and all nature)—not bad credentials for a kid of twenty-five. At least the blaauwbock got its scientific start from the best of a rising generation.

Since South Africa was then being settled by Dutch ancestors of the present Afrikaner people, zoological specimens from this part of the world tended to accumulate in collections within the Netherlands. Pallas must have seen several blaauwbock skins, for he began the description of his new species, *Antilope leucophaea,* by writing: "Hujus plurimas vidi pelles Promontoriae Bonae Spei missas" (I have seen several skins of this [species] sent from the Cape of Good Hope). Pallas described the blaauwbock in his *Miscellanea zoologica,* published in 1766. In those early days of zoology, when few species had been described, the Linnaean genus was defined more broadly, and all antelopes were placed into the single genus *Antilope*—as Pallas did for the blaauwbock. As more and more antelope species entered the rolls, this genus became unwieldy, and later taxonomists divided *Antilope* into several new genera, genealogically defined. The blaauwbock was therefore transferred, with its closest relatives, the roan and sable antelopes, into the new genus *Hippotragus.* Incidentally, Pallas did not name the blaauwbock for its blue color, but called it *leucophaea* (meaning dusky white) for a distinctive patch of light color under the eyes.

There can be little doubt that human activity drove the blaauwbock to extinctio European hunters certainly delivered t *coup de grâce,* but native African peop had introduced domestic sheep into t area as early as A.D. 400, and the resulti deterioration of habitat probably set an i evitable course for a species that had, f reasons not involving *Homo sapiens,* a ready become greatly reduced in numbe and geographic range. If ever a speci were marked for natural death in the el and flow of nature, surely the blaauwbo had already received its date with t Grim Reaper. No species are more vulne able than those combining large body si (and consequently small populations—t "more ants than elephants" principle) wi highly restricted ecological and ge graphic ranges. Sources differ on the e tent of the blaauwbock when first encou tered by Europeans, but most reports f the range to a tiny area, perhaps no mo than 60 miles (east–west) by 40 mil (north–south) in the province of Swelle dam, centered about 100 miles due east Cape Town. No large mammal with limited a range can long endure.



As a result of such rapid elimination f such a rare and restricted species, w know almost nothing about the blaauw bock. No reliable data on ecology or b havior were ever recorded in the wi (traveler's accounts are spotty, and oft secondhand or contradictory); with the e ception of one dubious skull and a few se of horn cores, we have no skeletal materi of blaauwbocks from the time of Eur pean settlement (some fossil bones pro ably belong to this species); even the fo mounted skins in European museums a too faded to yield knowledge of coloratio patterns in life. The blaauwbock passe into Western scientific consciousness an then, almost immediately, passed out existence entirely.

When vitality succumbs, we must mak do with the next best evidence—remnan and artifacts. The blaauwbock therefo moves to the world of curators. Preciou ness is often defined by rarity. On the grounds, hardly anything in natural hi tory can be more valuable than a scrap blaauwbock—and blessed the curator wh has one. In her monograph on the blaauw bock, Erna Mohr gives a complete a counting of all material in museums—an her list requires but three lines of text (*se* Erna Mohr, *Der Blaubock: Eine Doku mentation.* Hamburg; Paul Parey, 1967).

Only four mounted specimens exist— in the museums of Stockholm, Vienn Leiden, and Paris. Pairs of horns can b

und in Uppsala and London, and per-
ps in the Albany Museum of South
frica (the London blitz of 1941 de-
royed a lovely skull with horns once lo-
ted in the museum of the Royal College
Surgeons). The museum of Glasgow
uses a complete skull with horn cores
at may (or may not) be a blaauwbock's.
o other skins; no other bones. (Pallas's
iginal description cites "several skins
nt from the Cape of Good Hope," so
utch collections may once have held
ore specimens. But time and wars rav-
e our works as well as our bodies.) It is
sy to understand why the Leiden mu-
um treats its blaauwbock with such sin-
lar honor.

If my interaction with blaauwbocks had
ded with the specimen in its Leiden cab-
et, I doubt that I would have written this
say—a good story, yes; but no hook for
eater generality or extended contempla-
on. But Chris Smeenk then told me
mething else and gave me two articles to
ad—and these contributed a fact so
ignant and bittersweet that I had to pro-
ed. Smeenk told me that a debate had
isen as to which (if any) of the existing
ecimens had been among those ob-
rved by Pallas when he gave the blaauw-
ck its proper name. (Such questions are
t mere antiquarian indulgences. For le-
listic reasons in apportioning scientific
mes, all species must have a "type"
ecimen—a single preserved creature
at becomes the official name bearer for
e species. We need such types because
e often later discover that a named "spe-
es" really includes specimens from two
more legitimate species. We must then
tain the original name for one of these
ecies and coin new designations for the
hers. But which population gets to keep
e old name? By the rules of nomencla-
re, the original name belongs to the type
ecimen in perpetuity—and its popula-
on retains this first designation.)

Leiden had assumed for more than a
ntury that its mounted specimen had
en used by Pallas as one of the *plurimas*
lles (several skins) for defining *Hippo-*
agus leucophaeus. Since none of the
her skins can be traced, the Leiden spec-
nen therefore becomes the type—and, by
plication, the official and most impor-
nt specimen of the species (another rea-
n for Smeenk's pride in display). But
na Mohr had challenged this long-held
sumption and disestablished the Leiden
aauwbock to mere mortality as a speci-
en of uncertain provenance. If anything
n be called "fighting words" in the cura-

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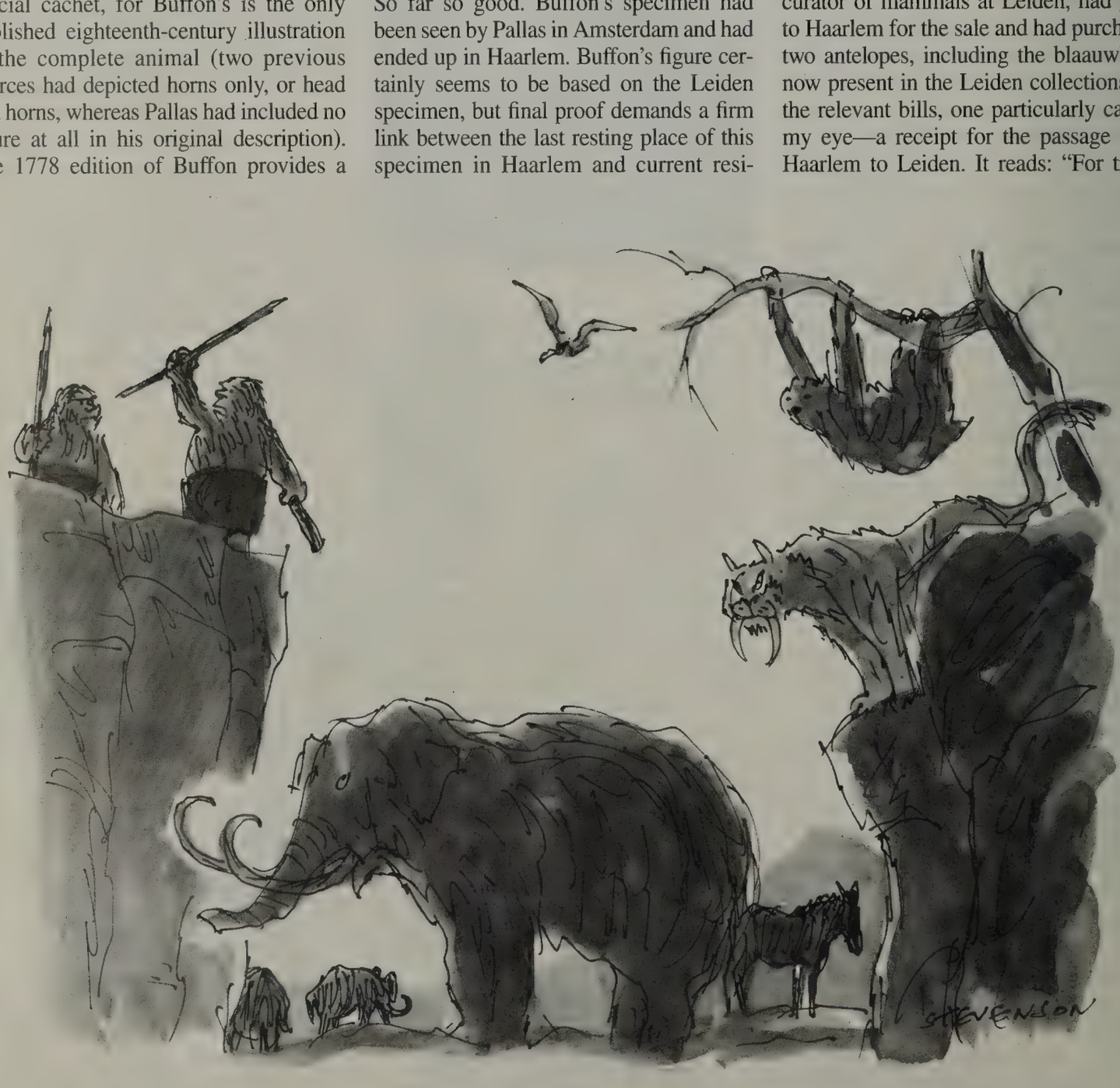
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torial world, Mohr had launched a haymaker (a real *chmallyeh,* as my grandfather, a true fan of pugilistic arts, would have said), and the curators of Leiden fought back—and won. Smeenk handed me two articles, published by Leiden curators A. M. Husson and L. B. Holthuis in 1969 and 1975 in the museum's publication *Zoologische Mededelingen.* The first paper reasserted the specimen's birthright in the title: "On the type of *Antilope leucophaea* Pallas, 1766, preserved in the collection of the Rijksmuseum van Natuurlijke Historie, Leiden."

Husson and Holthuis show that the Leiden blaauwbock is the same specimen figured in the 1778 edition of the standard eighteenth-century work in zoology—Buffon's *Histoire naturelle.* This identity already gives the Leiden blaauwbock a special cachet, for Buffon's is the only published eighteenth-century illustration of the complete animal (two previous sources had depicted horns only, or head and horns, whereas Pallas had included no figure at all in his original description). The 1778 edition of Buffon provides a good account of the history of this specimen: it had first been in the possession of Dr. J. C. Klöckner, a former physician on ships to the East Indies. Klöckner, who was well known for his skill in mounting specimens, lived in Amsterdam between 1764 and 1766, when Pallas published his description. Since we know that Pallas worked in Amsterdam, and tried to visit all major collections, he almost surely saw Klöckner's specimen—making the Leiden blaauwbock one of the *plurimas pelles* of Pallas's original description, and therefore the type of the species as the only identifiable specimen from the original lot.

Buffon's editor reports that the specimen then went to J. C. Sylvius van Lennep, a young patrician in Haarlem, and thence, upon his death in 1776, to the Holland Society of Sciences in the same city. So far so good. Buffon's specimen had been seen by Pallas in Amsterdam and had ended up in Haarlem. Buffon's figure certainly seems to be based on the Leiden specimen, but final proof demands a firm link between the last resting place of this specimen in Haarlem and current residence in Leiden. And here the trail ra cold—until Husson and Holthuis made th discovery that clinched the connection.

Mr. P. Tuyn, librarian of the Amsterda Zoo, found the smoking gun and gave th information to Husson and Holthuis. Tuy noted an advertisement in the April 1842, edition of the *Opregte Haarlemsch Courant* announcing the sale by auction o part of the Holland Society's zoologic collections—and the text of the ad ind cated that a blaauwbock had been in cluded among the items. Husson an Holthuis then burrowed into the Leide museum archives and found a stack o bills submitted by the museum to its fun ing agency, the Ministry of Internal A fairs (remember that the museum then en joyed royal patronage), on May 31, 184 The bills prove that Dr. H. Schlegel, the curator of mammals at Leiden, had gon to Haarlem for the sale and had purchase two antelopes, including the blaauwboc now present in the Leiden collections. O the relevant bills, one particularly caug my eye—a receipt for the passage fro Haarlem to Leiden. It reads: "For tran



"It always happens.... I get this far and I forget what I'm supposed to bring home."

rtation: for the towbarge f. 2.00, for the ntelopes f. 0.60. For delivery f. 0.85. For nsumptions f. 0.75. For purchase of the telopes f. 47.10. Total f. 51.30."

I don't know why this degree of detail fected me so powerfully. Just think what timate circumstances we can recover in acing a case—three-quarters of a florin ncestor of the present Dutch guilder) for er and sausage to keep the bargemen in od spirits as they brought the blaauw-ck from Haarlem to Amsterdam. Yet the aauwbock itself, as a living, evolving tural entity, is gone—extinct before we ew its preferred food, its voice, the color its hide. When the pith and essence dis-pear, we are reduced to arguing over raps and relics. We cry over Anne ank's notebook; we kneel in reverence, cording to our creed, before a scrap of ebone of the Great Buddha, or a vial of e supposedly liquefying blood of Saint nuarius. We must care about the barge-en's lunch because it has become our nk to something beautiful that we lost.

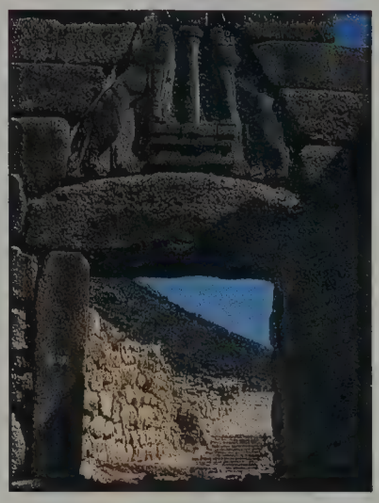
Curators may be guardians of the sec-nd best, but when we have lost the living human malfeasance, what can be more sidually noble than faithful preservation nd accurate documentation of often tiable fragments?

This sadness spawns respect for our ter compassion and need to preserve—o little and too late for the blaauwbock, t a lesson perhaps when we tote the rel-ive worth of a healthy species versus a ceipt 150 years old. An unknown ele-ent in the periodic table will one day be ade or discovered—for phenomena in ch simple and law-bound systems enjoy redictability and repeatability. But when e lose all evidence for a historical item, e cannot reconstruct what we did not reserve—for we have extinguished part nature's unique richness forever. The aauwbock came within a hair of total ex-pation from memory (as well as from frica). But we knew this species for a w years during part of a century, and we d save a few scraps and records—miser-ble, tawdry fragments in one sense, yet agical in another, and therefore of pre-ous rarity, as the only witnesses to a first ss in an accelerating series. They are atching us from Leiden, Paris, Vienna, nd Stockholm. Four antelopes of the pocalypse, silently watching to see how any we will bring to their sorry fate.

tephen Jay Gould teaches biology, geol-gy, and the history of science at Harvard niversity.

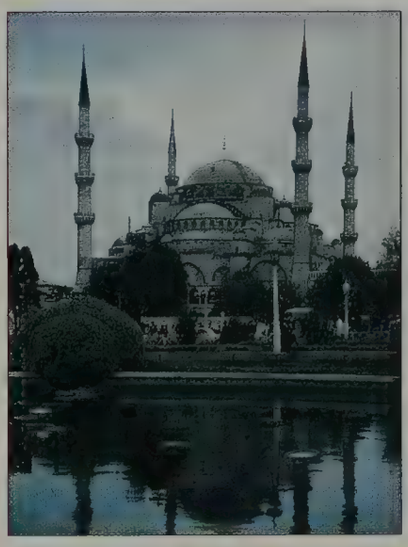
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Rediscover Your World

What Are Men Good For?

Big-game hunting by men may have evolved for reasons other than to nourish wives and children

by Jared Diamond

When I first began to work in the New Guinea highlands, I often became enraged when I saw how grossly women were abused. Along jungle trails I encountered married couples, the woman typically bent under a huge load of firewood and vegetables, carrying an infant, while her husband sauntered along, bearing nothing more than his bow and arrow. Men's hunting trips seemed to be little more than male-bonding opportunities, yielding only a few prey animals consumed on the spot by the hunters. Wives were bought, sold, and discarded without their consent.

Later, when I had children of my own and shepherded my family on walks, I felt I could better understand the New Guinea men striding beside their families. The men were functioning as lookouts and protectors, keeping their hands free so that they could quickly deploy their bows and arrows in the event of an ambush by men of another tribe. But the men's hunting trips and the sale of women as wives continue to trouble me.

The question "What are men good for?" may sound like a flip one-liner, but it touches a raw nerve in our society. Women are becoming intolerant of men's self-ascribed status and are criticizing those men who provide better for themselves than they do for their wives and children. The question is also a theoretical problem for anthropologists. In terms of services offered to mates and children, males of most mammal species are good for nothing but injecting sperm. They part from the female after copulation, leaving her to bear the entire effort of feeding, protecting, and training the offspring. But human males differ by (usually) remaining with mates and offspring. A widespread assumption among anthropologists is that men's familial roles contributed crucially to the evolution of our species' most distinctive features. The reasoning is as follows.

Men's and women's economic roles differ in all surviving hunter-gatherer societies, a category that encompassed all human societies until the rise of agriculture 10,000 years ago. Men invariably spend more time hunting large animals, while women spend more time gathering plant foods, trapping small animals, and caring for children. Anthropologists traditionally argue that this division of labor arose because it promoted the nuclear family's joint interests and thereby represented a sound, cooperative strategy. Men are much better able than women to track and kill big animals, for the obvious reason that men don't have to carry infants around to nurse them. In the view of most anthropologists, men hunt in order to provide meat for their wives and children.

A similar division of labor persists to some degree in modern industrial societies, since most women still devote more time to child care than men do. While hunting is no longer an important male occupation and women now work outside the home, men still provide for their spouses and children by holding paying jobs. Thus, the expression "bringing home the bacon" has a profound and ancient meaning.

Meat provisioning is considered a distinctive function of human males, shared with only a few other mammal species, such as wolves and African hunting dogs. Like many other primate males, men protect their mates and their offspring, but that service is viewed as less of a net contribution by men to society than is hunting, since men defend their families mainly from other men. Meat provisioning is assumed to be linked to other uniquely human features, in particular the continued association of men and women in nuclear families after copulation and the in ability of human children (unlike youn apes) to obtain their own food for man years after weaning.

From this theory, the correctness o which is generally taken for granted, fol low two straightforward predictions abou men's hunting: First, if the main purpos of hunting is to bring meat to the hunter' family, men should pursue the huntin strategy that reliably yields the most meat Hence the presumed explanation for men' hunting big animals is that they thereb bag, on average, more pounds of meat pe day than by hunting small animals. Sec ond, a hunter should be expected to brin his kill to his wife and children, or at leas to share it with them preferentially. But d the two predictions square with reality?

Surprisingly, neither assumption ha been much tested. Less surprisingly, per haps, a woman anthropologist has take the lead in testing them. Kristen Hawkes of the University of Utah, has studie Paraguay's Northern Aché Indians, mea suring their foraging yields in a study car ried out jointly with Kim Hill, A. Mag dalena Hurtado, and H. Kaplan. I collaboration with Nicholas Blurton Jone and James O'Connell, Hawkes conducte other tests based on the practices of Tanza nia's Hadza people.

The Northern Aché used to be full-tim hunter-gatherers, and they continued t spend much time foraging in the fores even after they began to settle at missio agricultural settlements in the 1970s. Ach men hunt large mammals, such as pecca ries and deer, and also collect masses o honey from bees' nests. Women poun starch from palm trees, gather fruits an insect larvae, and care for children. Th contents of an Aché man's hunting ba vary greatly from day to day. He bring



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home enough food for many people if he kills a peccary or finds a beehive, but he gets nothing at all on one-quarter of all days spent hunting. In contrast, women's returns vary little from day to day because palms are abundant: how much starch a woman gets depends mainly on how much time she spends pounding it. A woman can always count on getting enough for herself and her children, but she can never reap a bonanza big enough to feed many others.

The first shock resulting from the studies by Hawkes and her colleagues concerned the difference between the returns achieved by men's and women's strategies. Peak yields were, of course, much higher for men than for women, since a man's daily bag topped 40,000 calories when he was lucky enough to kill a peccary. However, such glorious days are greatly outnumbered by the humiliating days when he returns empty-handed. A man's average daily return of 9,634 calories per day proved to be lower than that of a woman (10,356), and a man's median return (4,663 calories per day) was even lower.

Thus, Aché men would do better in the long run by sticking to the unheroic "women's job" of pounding palms than by devoting themselves to the excitement of the chase. Since they are stronger than women, men could, if they chose to, pound even more daily calories from palm starch than can women. In going for high but very unpredictable returns, Aché men can be compared with gamblers who aim for the jackpot, even though in the long run the gamblers would do much better by putting their money in the bank and collecting the boringly predictable interest.

The other shock was that successful hunters do *not* bring meat or honey home mainly for their wives and children, but share it widely. Women share also, but not so widely as men. As a result, three-quarters of all food that an Aché consumes is acquired by someone outside the consumer's nuclear family.

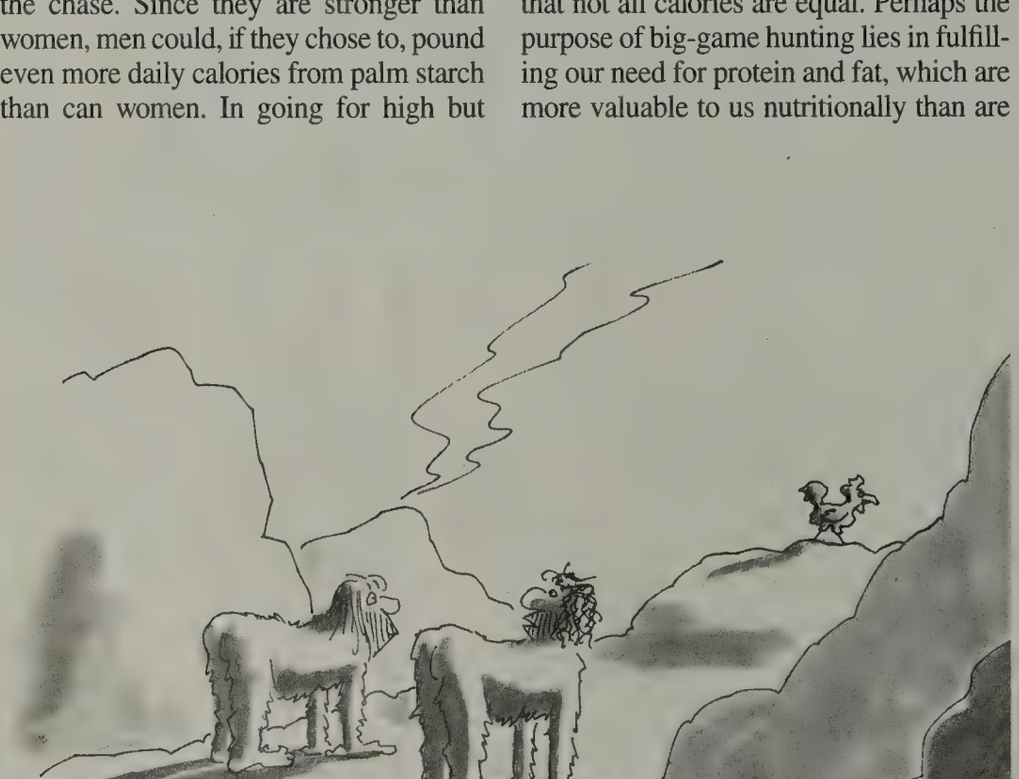
These findings suggest that something other than the best interests of his wife and children lies behind an Aché man's preference for big-game hunting. As Kristen Hawkes described these paradoxes to me, I began to develop an awful foreboding that the true explanation might prove less noble than the necessity of bringing home the bacon. I began to feel defensive about my fellow men and searched for explanations that might restore my faith in the nobility of our strategy.

My first objection was that Kristen Hawkes's calculations of hunting returns were measured in calories. In reality, any nutritionally aware modern reader knows that not all calories are equal. Perhaps the purpose of big-game hunting lies in fulfilling our need for protein and fat, which are more valuable to us nutritionally than are the humble carbohydrates of palm starch. However, Aché men target not only protein-rich meat but also honey, whose carbohydrates are every bit as humble as those of palm starch. While Kalahari San men (Bushmen) are hunting big game, San women are gathering and preparing mongongo nuts, an excellent protein source. While lowland New Guinea hunters are wasting their days in the usually futile search for kangaroos, their wives and children are predictably acquiring protein in the form of fish, rats, grubs and spiders. Why don't San and New Guinea men emulate their wives?

I next began to wonder whether Aché men might be unusually ineffective hunters, a modern aberration among hunter-gatherers. Undoubtedly, the hunting skills of Eskimo and Arctic Indian men are indispensable, especially in winter, when little food other than big game is available. Tanzania's Hadza men, unlike the Aché, achieve higher average returns by hunting big game more than small game. But New Guinea men, like the Aché, persist in hunting even though yields are very low. And Hadza hunters persist in the face of enormous odds, since on most hunting days they bag nothing at all. A Hadza family could starve while waiting for the husband/father to win his gamble of bringing down a giraffe. In any case, from the family's point of view, it is an academic question whether big-game hunting yields higher or lower returns than alternative strategies, since all the meat occasionally bagged by a Hadza or Aché hunter isn't reserved for the family.

Still seeking to defend my fellow men, I then wondered: Does widespread sharing of meat and honey smooth out hunting yields, constituting a form of reciprocal altruism? That is, I expect to kill a giraffe only every twenty-ninth day, and so does each of my hunter friends, but we all go off in different directions, and each of us is likely to kill our giraffe on different days. If successful hunters agree to share meat with the rest of the social group, most people will have full bellies most of the time. According to this scenario, hunters would share their catch with the best other hunters, those from whom they are most likely to receive meat in return.

In reality, though, successful Aché and Hadza hunters share their catch with anyone, regardless of whether he's a good or hopeless hunter. That raises the question of why an Aché or Hadza man should bother to hunt at all, since he can claim a share of meat even if he never bags any



"Someday, Og, man too will walk upright."

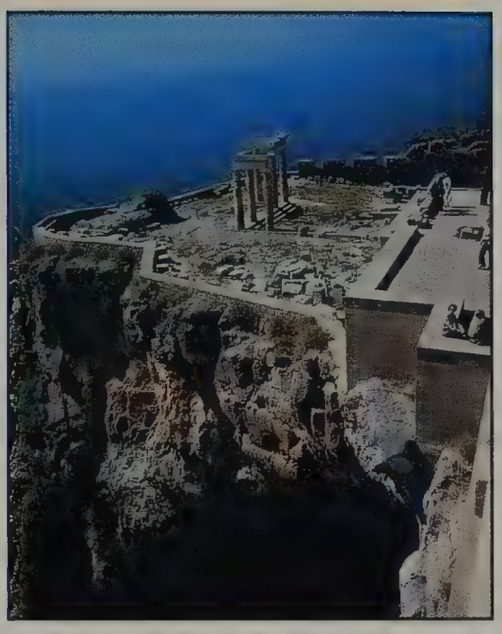
ng himself. Conversely, why should he
nt when any animal that he kills is
ared widely? Why doesn't he just gather
ts and rats, which he can bring to his
nily exclusively?

As my last defense (objection?) I hy-
thesized that wide sharing of meat helps
e hunter's whole tribe, which is likely to
urish or perish together. It's not enough
concentrate on nourishing your own
nily if the rest of your tribe is starving
d can't fend off an attack by tribal ene-
es. But that line of reasoning brought
e back to the original paradox: The best
y for the whole Aché tribe to become
ll nourished is for all to humble them-
lves, by pounding good old reliable
lm starch and collecting fruit or insect
vae. The men shouldn't waste their time
mbling on the occasional peccary.

Thus collapsed all four of my efforts to
fend Aché big-game hunting as a sensi-
e way for men to contribute nobly to the
st interests of their wives and children.
isten Hawkes then drove home some
inful truths, reminding me that the Aché
an himself (and not his wife and chil-
en) gets big benefits from his kills.

To begin with, among the Aché, as
nong most other peoples, extramarital
x is not unknown. Dozens of Aché
omen, asked to name the possible fathers
ex partners at the time of conception) of
ty-six of their children, named an aver-
e of 2.1 men per child. (Before you con-
mn Aché women as exceptionally loose,
flect that genetic markers show that 5
rcent to 40 percent of American and
itish babies have been sired by a man
ner than the mother's spouse. And these
mbers underestimate the frequency of
ultery, because not every bout of adul-
y results in conception.) When asked
out a sample of twenty-eight Aché men,
omen named good hunters more often
an poor hunters as their lovers, and
med good hunters as possible fathers of
ore of their children.

To understand the biological signifi-
nce of adultery, recall that the facts of
productive biology introduce a funda-
ental asymmetry into the interests of
en and women. Multiple sex partners
ntribute nothing directly to a woman's
productive output. Once a woman has
d an ovum fertilized by a man, having
x with another man cannot lead to an-
her baby for at least nine months, and
obably for at least several years under
nter-gatherer conditions of extended
ctational amenorrhea. In a few adulter-
us minutes, though, a married man



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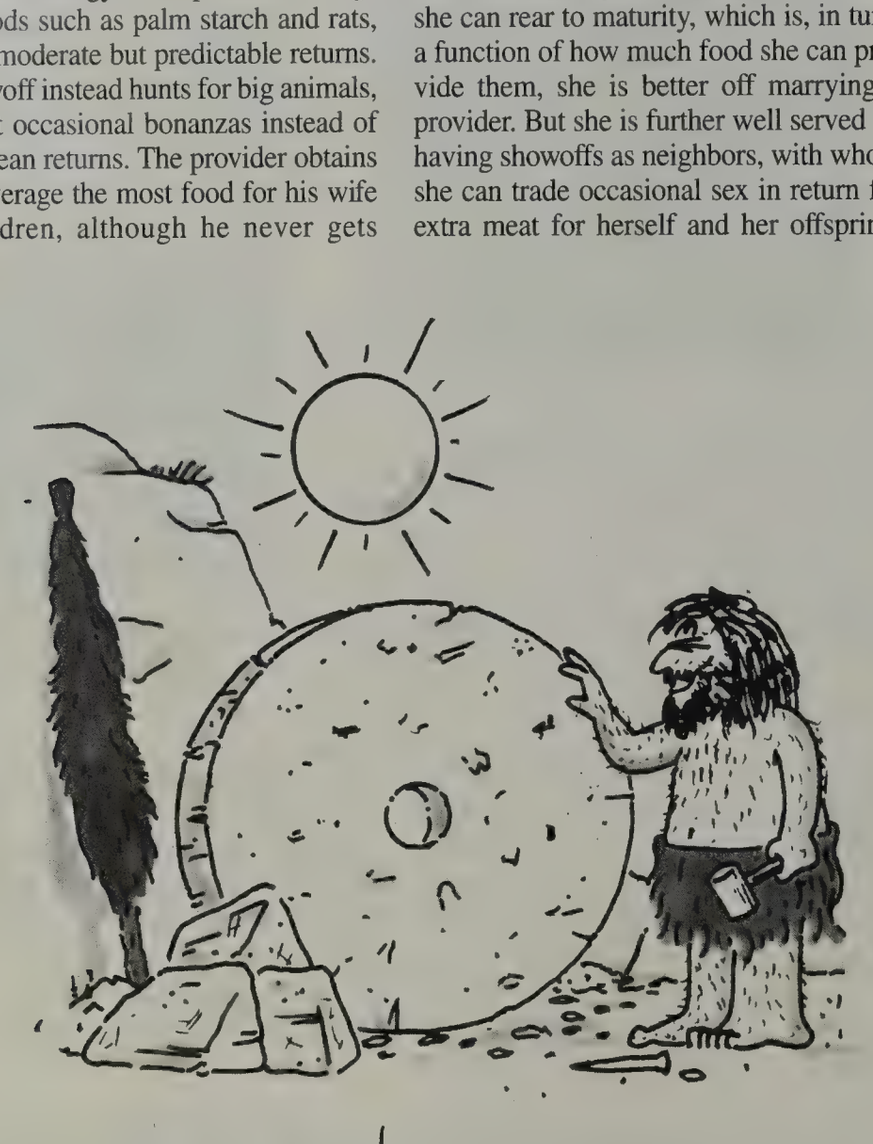


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may increase his total number of children.

Now compare the reproductive outputs of two hypothetical men pursuing the two different hunting strategies that Hawkes terms the "provider" strategy and the "showoff" strategy. The provider brings home foods such as palm starch and rats, yielding moderate but predictable returns. The showoff instead hunts for big animals, aiming at occasional bonanzas instead of higher mean returns. The provider obtains on the average the most food for his wife and children, although he never gets enough of a surplus to feed anyone else. The showoff usually brings less food to his wife and children, but does occasionally get lots of meat to share with others.

Obviously, if a woman gauges her genetic interests by the number of children she can rear to maturity, which is, in turn, a function of how much food she can provide them, she is better off marrying a provider. But she is further well served by having showoffs as neighbors, with whom she can trade occasional sex in return for extra meat for herself and her offspring.



The whole tribe also likes a showoff be cause of the occasional bonanzas that h brings home for sharing.

In terms of advancing his own geneti interests, the showoff gains advantages a well as disadvantages when compare with the provider. One advantage is th extra offspring sired adulterously, as I'v already explained. But the showoff als gains prestige in his tribe's eyes. Others i the tribe want him as a neighbor becaus of his gifts of meat, and they may reward him with their daughters as wives. For th same reason, the tribe is likely to give fa vored treatment to the showoff's children Disadvantages are that the showoff's les reliable provisioning of his own family may mean that he may have fewer legiti mate children reaching maturity. Th showoff's wife may also philander, s some of her children may not be his. Is th showoff better off giving up the provider' certainty of fathering of a few children i return for the possibility of fathering many children?

The answer depends on several num bers, such as the extra number of legiti mate children that a provider's wife ca rear, the percentage of a provider's wife' children that are legitimate, and the poten tial extra survivorship that a showoff's off spring may gain from their favored status The answer may differ among tribes, de pending on the local ecology. For th Aché, Hawkes estimates that over a wid range of likely conditions, showoffs ca expect to pass on their genes to more sur viving children than can providers. Thi fact, rather than the traditionally accepte view of bringing home the bacon to wif and children, may be the motive reaso behind big-game hunting. Aché me thereby do good for themselves rathe than for their families.

Thus, men hunters and women gather ers don't always constitute a division o labor whereby the family unit most effec tively promotes its joint interest. They als don't constitute an arrangement in whic the work force is selectively deployed fo the good of the group. Instead, the hunter gatherer life style involves a classic con flict of interest, in which what's best for man isn't necessarily best for a woman an vice versa. Spouses share interests but als have divergent interests. A woman is bet ter off married to a provider, but a man i not better off being a provider.

Biological studies in recent decade have demonstrated many such conflicts o interest in animals and humans: not onl conflicts between husbands and wives (o

tween mated animals) but also between rents and children and among siblings. hile biologists explain the conflicts theotically, all of us recognize them from exrience, without doing any calculations genetics and foraging ecology. Conflicts interest between spouses and close latives are the commonest, most gutrenching tragedies of our lives.

How generally can these findings be apied? The conclusions of Hawkes and her lleagues await testing for other huntertherers. The answers are likely to vary nong tribes and even among individuals. om my experience in New Guinea, awkes's conclusions are likely to apply en more strongly there. New Guinea has w large animals, hunting yields are low, d empty bags are frequent. Men conme much of their catch while they are f in the jungle; and when big animals are ought home, the meat is shared widely. ew Guinea hunting is hard to defend onomically, but it brings obvious payfs in status to successful hunters.

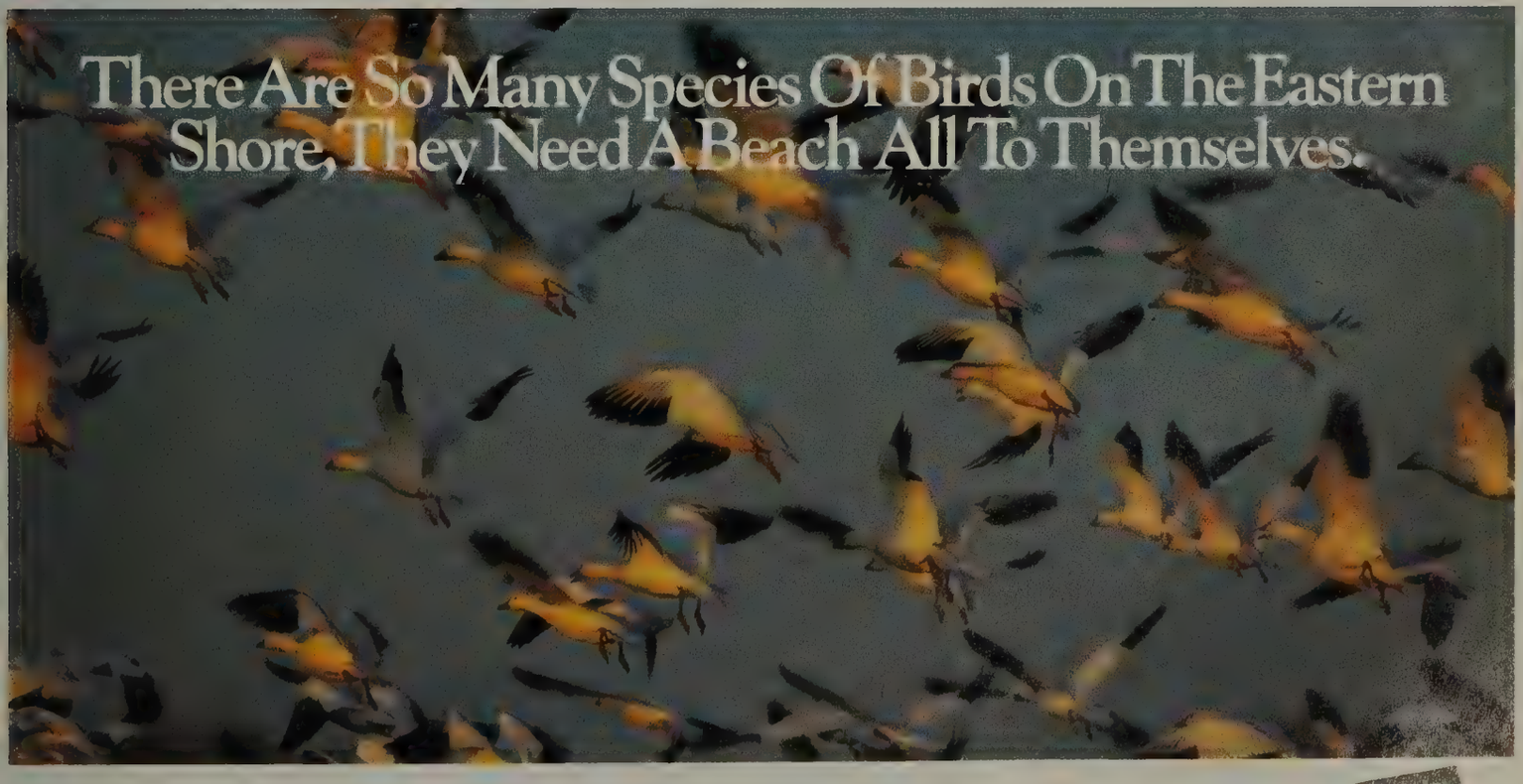
What about the relevance to our own ciety? Perhaps you're already livid beuse you foresaw that I'd raise that quesn, and you're expecting me to conclude that American men aren't good for much. Of course that's not what I conclude. I acknowledge that many (most? by far the majority of?) American men are devoted husbands, work hard to increase their income, devote that income to their wives and children, do much child care, and don't philander.

But, alas, the Aché findings are relevant to at least some men in our society. Some American men do desert their wives and children. The proportion of divorced men who renege on their legally stipulated child support is scandalously high, so that even our government is proposing to do something about it. Single parents outnumber co-parents in the United States, and most of those single parents are women.

Among those men who remain married, all of us know some who take better care of themselves than of their wives and children, and who devote inordinate time, money, and energy to philandering and to male status symbols and activities, such as cars, sports, and alcohol consumption. Much bacon isn't brought home. I don't claim to have measured what percentage of American men rate as showoffs rather than providers, but the percentage of showoffs appears not to be negligible.

Even among devoted working couples, time budget studies show that American working women spend on the average twice as many hours on their responsibilities (defined as job plus children plus household) as do their husbands, yet women receive on the average less pay for the same jobs. When American husbands are asked to estimate the number of hours that they and their wives each devote to children and household, the same time-budget studies show that men tend to overestimate their hours and to underestimate their wives' hours. It's my impression that men's household and child-care contributions are on the average still lower in some other industrialized countries, such as Australia, Japan, Germany, France, and Poland, to mention a few with which I happen to be familiar. That's why the question "What are men good for?" continues to be debated within our societies, as well as among anthropologists.

Jared Diamond, a professor of physiology at UCLA Medical School, does biological exploration in New Guinea.



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V I R G I N I A

Off the Wall

Kilroy strikes again

by Roger L. Welsch

I had never even heard the word "graffiti" until the fall of 1964, when a marvelous old scholar by the name of Allen Walker Read, of Columbia University, presented a paper on the phenomenon at the annual meeting of the American Folklore Society. Professor Read wrote and spoke with elegance. His observations were remarkable—for example, that in the thirty years he had been collecting graffiti in the New York City subway system, he had never seen anyone write any.

My favorite graffito of his corpus amazed me with its simplicity. An organization was promoting literacy by distributing posters around New York that declared "The pen is mightier than the sword." Someone with a mind a good deal more complicated than mine had taken a marking pen and put two simple strokes on one of the posters that made a counter-comment, expressed a valid, if profane, philosophy, and brought a smile to almost everyone who saw it. The graffitist nicked in a small comma following the word "is" and drew a short, curved, subscript line joining the "is" to the word preceding it.

Read was a great performer, which certainly was a part of the attraction his work held for me, and I was ready to be impressed by almost anything called "folklore," since I had just begun my own study (a calling if there ever was one). But the most impressive thing to me was the art and wit of graffiti at that time. This was three decades ago, when even people who wrote for a living looked to graffiti for inspiration. The title "Who's Afraid of Virginia Woolf?" was a graffito before it appeared on a Broadway marquee. Same with "Stop the World, I Want to Get Off."

In the third-floor bathroom for the English Department at the University of Nebraska, I watched with joy as this dialogue developed on a toilet stall door:

"I love grils."

"That's 'girls,' stupid, 'g-i-r-l-s.' "

"Well, then what about us grils?"

Visits to even the most disreputable restrooms became adventures as the art and wit of graffiti reached their zenith in the seventies and eighties, mirroring all manner of causes—civil rights, the agonies of Vietnam, the sexual revolution, women's liberation. And always the gentle nonsense: "The earth is flat," someone wrote on the wall of the men's room in the Dannebrog tavern, signing it, "Class o 1491." And it was in an Iowa truck stop on a vending machine for prophylactics that I saw, "This gum tastes like rubber."

Now, maybe I'm just getting old, but th urban graffiti I see today just don't seem a entertaining. There are institutionalize graffiti—murals sponsored by arts coun cils and executed by recognized and ac complished street artists or even studio trained artists. And there are gang-, turf- and person-centric identifiers, occasion ally displaying a decorative sense, bu more often than not amounting to simpl architectural mutilation.



Why We Need A Smaller U.S. Population And How We Can Achieve It

We need a smaller population in order to halt the destruction of our environment, and to create an economy that will be **sustainable** over the very long term.

We are trying to address our steadily worsening environmental problems without coming to grips with their root cause -- overpopulation.

If present immigration and fertility rates continue, our population, now over 254 million, will pass 400 million by the year 2050 -- and still be growing rapidly!

All efforts to save our environment will ultimately be futile unless we not only halt U.S. population growth, but reverse it, so that our population can eventually be stabilized at a **sustainable** level -- far lower than it is today.

The Optimum U.S. Population Size

The central issue is surely this: **At what size should we seek to stabilize U.S. population?** Unless we know in what direction we should be headed, how can we possibly devise sensible policies to get us there?

The size at which our population is eventually stabilized is supremely important because of the effect of sheer numbers of people on such vitally important national goals as a healthy environment, and a sustainable economy.

We believe these goals can best be achieved with a U.S. population in the range of 125 to 150 million, or about its size in the 1940s. This optimum size could be reached in about three to four generations if we do two things now that are well within our grasp.

How To Get There

1. **Reduce annual immigration to about 200,000** so that it is in rough balance with emigration (out-migration). Then, immigration will no longer contribute significantly to our population growth, as it does now.

2. **Lower our fertility rate** (the average number of children per woman) from the present 2.1 to around 1.5 and maintain it at that level for several decades. We believe that non-coercive financial incentives will be necessary in order to reach that goal.

If almost all women had no more than two children, our fertility rate would drop to around 1.5, because many women remain childless by choice, or choose to have not more than one child. **We promote the ideal of the two-child maximum family as the social norm, because that is the key to lowering our fertility.**

Incentives to Lower Fertility

NPG proposes these incentives to motivate parents to have no more than two children:

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- Give a Federal income tax credit **only** to those parents who have not more than two children. Those with three or more would lose the credit entirely.
- Give an annual cash grant to low income parents who pay little or no income tax, and who have no more than two children. Those with three or more would lose the cash grant entirely.

Two Vastly Different Paths Lie Before Us

With the reductions in immigration and fertility we advocate, our nation could start **now** on the path toward a sustainable, and prosperous, population of 125 to 150 million.

Without such a program, we are almost certain to continue our mindless, headlong rush down our current path. That path is leading us straight toward catastrophic population levels that can only devastate our environment, and produce universal poverty in a crowded , polluted nation.

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The blight is not confined to our larger cities. In Grand Island, Nebraska, population 39,000, front-page articles in the *Grand Island Independent* have recently expressed considerable concern about the arrival of graffiti, because they appear to be territorial declarations by rival gangs. Not even Dannebrog (population 320) remains untouched. Last summer some people—almost certainly children—ranged through town with spray cans, spraying mailboxes, commercial buildings, and road signs with (yikes) happy faces, along with a generous sprinkling of a very Anglo-Saxon word.

"Someone ought to wring those kids' necks," I said.

"Well," sighed Slick-up-at-the-tavern, "We can take some comfort in the fact that the spray painting wasn't done by kids from Dannebrog."

I looked at Slick with surprise. "How do you know it wasn't done by someone from this town?"

"They spelled it right," he explained.

When did this need to make one's mark on the public walls begin? It certainly didn't begin with aerosol cans. In almost every state of the Union, hikers, prospectors, and sportsmen find ancient Indian petroglyphs (a fancy word for graffiti) tucked away in sheltered rock nooks and crannies: animals real and imagined, spirits, human figures, swirls, lines, coils, waves—and handprints. Handprints chipped out of the rock, painted with colored earth or blood, silhouetted by dyes blown from the graffitist's mouth against his hand held to the rock. Some of the designs may be symbolic, mystic, artistic, but I suspect that a lot of them came about when, say, Lone Elk, a Cheyenne, put his clear mark—the very image of hi hand!—in a sheltered cave almost certai to be visited eventually by Black Bear, th Lakota—who would understand that i says, "Cheyenne Rule!" and lose his cool

Along with corpses, horses, house wares, riches, and tools discovered buried in the ash of Pompeii, graffiti were found scrawled on the walls of the city, of homes of businesses: "Claudio loves Flavia," "Gaius is a jerk," that kind of thing. And there were swirls, lines, coils, waves, and handprints. And we know what that means.

We stand in awe of the paleolithic cave paintings of Lascaux and duplicate them in museum exhibits. We regard them as art and symbol. We wonder at their meanings. Were they meant to conjure up game for the hunters or sex for the lonely or perhaps progeny for the barren? Were they messages for man or beast or the gods? Were they mnemonic devices or illustrations for narrators? Or art—beauty for beauty's sake?

I'm willing to bet that some of the cave decorations were admired by contemporary visitors, and others were considered clumsy mutilations. Some were simple declarations of tribal and individual existence—"We were here," "I was here." Some were probably the product of too much time and leftover paint. And I'll bet that, people still being pretty much people, some of those designs and markings say something like, "Ask God in prayer and She will answer." Or "Neanderthal Rule." Or "Og loves Glom." Or "Cro Magnons Go Home."

Folklorist Roger L. Welsch lives on a tre farm in Dannebrog, Nebraska.



"Best 'Filet Magnon' I've had in a while!"

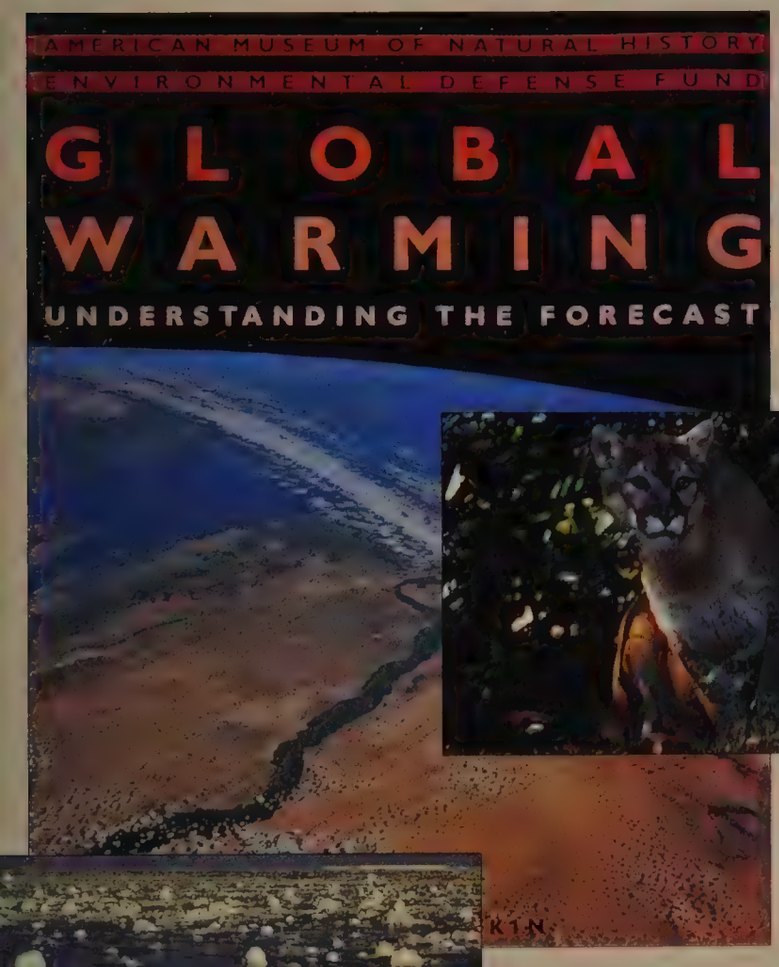
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Patrick Sorgeloos

Sex and the Single Brine Shrimp

Around the Mediterranean, female brine shrimp have been reproducing—without help from males—for millions of years

by Robert A. Browne

Mention southern France, Provence in May, and people often imagine the vibrant, flowered landscapes of van Gogh's paintings. From where I stand, ankle deep in a salt pond, I gaze across the Camargue towards Arles and Saint Remy, where the painter lived during his most prolific period. Morning hues of umber and gold reflect from the distant hills of the Alpilles. In the other direction, a few yards away, the Mediterranean laps gently against a clay embankment. Close by in the pond, pink flamingos feed, using their highly specialized beaks to sieve the plankton-rich water. Lowering my net to do the same, I startle them into flight.

Despite the idyllic surroundings, the aquatic life at my feet faces severe challenges. Seconds after I withdraw my hand from the shallow pond, the water on me evaporates, leaving my fingers encrusted with salt. The water here is 30 percent salt, nearly ten times saltier than the Mediterranean just a few feet away. A list of plant and animal species contained in a sample of the seawater would be long, but a list of plankton in a similar volume of the pond water would be sharply abbreviated. Few species can survive in the highly saline water, which (because of osmotic pressure) tends to extract water from an animal's cells upon contact; without proper protection, small planktonic organisms suffer fatal dehydration in such an environment. Communities that live in hypersaline ecosystems are therefore among the simplest on earth, often consisting of one species of alga, usually in the genus *Dunaliella,* and one grazer, the brine shrimp, *Artemia.*



Shortly after being placed in water, a brine shrimp, left (magnified 150 times), emerges from a cyst. Greater flamingos, above, feed on brine shrimp in the salt ponds of the Camargue in France.

Farrell Grehan: Photo Researchers, Inc.

Despite ribbings by colleagues, I am not interested in this ecosystem merely because of the admittedly pleasant surroundings (which include nearby nude beaches). I am here to study brine shrimp, which are not closely related to true shrimp but instead are Branchiopoda, a specialized branch of Crustacea that also includes water fleas. Brine shrimp are superbly adapted to the severe physiological demands imposed by hypersaline ecosystems. Cloaked in a nearly impenetrable exoskeleton and able to pump out excess salt, they can tolerate a wider salinity range than any other multicellular organism. They are familiar to tropical fish enthusiasts and aquaculturists as the dry brown "eggs" that are sprinkled into water as food. The half-inch-long adults are also advertised in comic books and similar highbrow literature as sea monkeys that "dance and court before your very eyes."

The populations that I am studying are entirely female and reproduce by parthenogenesis, that is, reproduction without males through the development of an unfertilized egg. Upon maturity, the eggs simply begin to develop into another generation of females. Parthenogenesis occurs throughout the animal kingdom (including lizards, amphibians, fish, and numerous invertebrates), but only a few, like these brine shrimp, are obligately parthenogenetic.

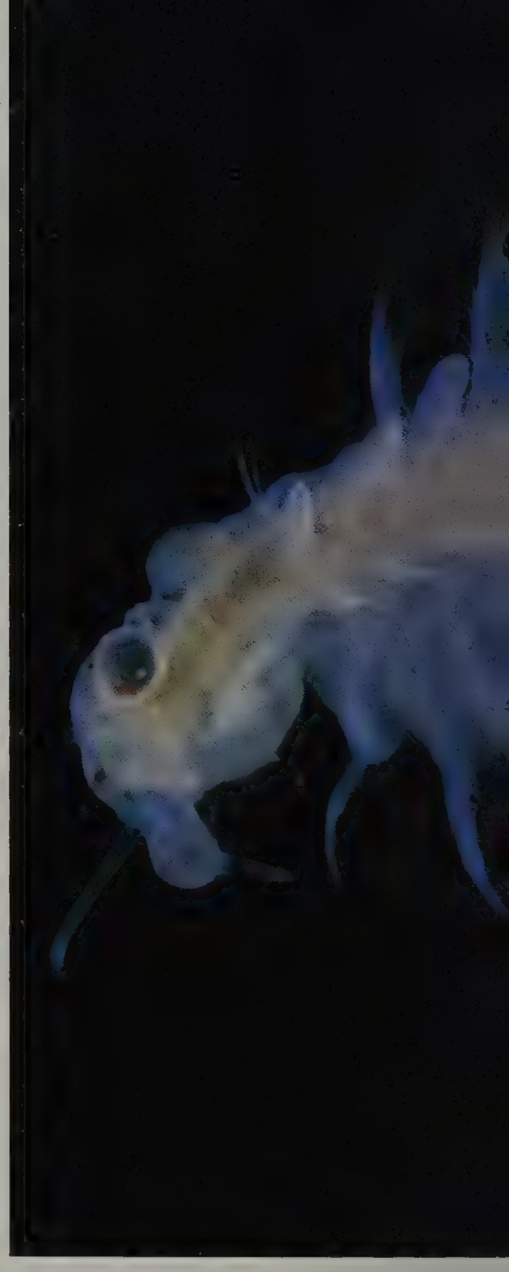
Such asexual reproduction supposedly results in nearly identical clones generation after generation, but at this location in southern France, I found at least sixty different genetic strains, with highly variable life strategies. This raises a number of questions. How did the population become so variable? Why do most populations of

A female brine shrimp, right, carries eggs that may develop into cysts, which can survive for years in a dormant state, or into nauplii, below, which can swim at birth. Genetics and environmental conditions determine which reproductive strategy is taken.

Both photographs by Ernest Cooper; Vancouver Public Aquarium



×75



Old World brine shrimp reproduce asexually while New World brine shrimp are sexual? And are parthenogenetic populations evolutionary "dead ends" since they are incapable of sexual recombination, the supposed key to adaptability and survival?

The delta at the mouth of the Rhône River, where I conduct my research, has more than 100 interconnected ponds of various sizes, depths, and salinity levels, making it an excellent area to study brine shrimp. Called the Salin de Giraud, it is a saltworks, where salt has been commercially extracted from seawater since Roman times. The sun evaporates water from 47 square miles of ponds, making the operation one of the largest in the world.

After about a year, enough water has evaporated from the ponds for the salts from the seawater to begin crystallizing. The various salts, such as magnesium chloride, sodium sulfate, and sodium chloride, precipitate at different saturation levels and hence can be separated. Primitive, labor-intensive procedures persist at many saltworks but at Salin de Giraud and nearby Aigues-Mortes (literally, "dead water"), front-end loaders scrape the salt into huge piles to be processed mostly for the petrochemical industry, with only a small amount sold as table salt.

Brine shrimp thrive in the ponds where the salinity is high enough to exclude fish predators (approximately 5 percent) up to the point at which salt crystallizes (more than 28 percent). However, recent research has shown that their life cycle can be completed only in a narrower range (5 to 20 percent). Because they are filter feeders and continuously remove algae and debris from the water, they enhance the water clarity, which allows more light to be absorbed by the dark pond bottoms, increasing the evaporation rate and extraction efficiency. The presence of brine shrimp in saltworks is so desirable that if they are not already present, they are usually introduced into the ponds.

In the New World, three sexual species of *Artemia* occur. *A. persimilis* is found only at Hidalgo, Argentina, and is reproductively isolated from other sexual species by an additional pair of chromosomes (44 chromosomes rather than 42). *A. monica* is found only at Mono Lake in California, where an unusually high level of boron gives the lake a unique water chemistry. The third, *A. franciscana,* has natural populations scattered throughout North and South America, the Caribbean, and the Pacific Islands. Virtually all eggs (which are actually encysted embryos) sold in the United States are *A. franciscana* and come from the Great Salt Lake in Utah or from the San Francisco Bay area. *A. franciscana*, however, has been widely introduced by humans for aquaculture and high-quality salt production and is now found in Southeast Asia, Australia, and New Zealand, and was recently found in Spain and Kenya. As do many exotics, *A. franciscana* is raising concerns that it will displace native populations, as laboratory experiments done by my co-workers and me show that it can rapidly outcompete native species.

Two additional sexual species occur in the Old World. *A. tunisiana* occurs in Spain, North Africa, Sardinia, and Cyprus. *A. urmiana* had been reported only from Lake Rezaiyeh (also known as Lake Urmia), Iran, but recent evidence suggests that this species occurs in central China and perhaps in other Asian locations.

At Salin de Giraud, water is present year-round in at least some of the ponds, but at other locations where I have worked such as North Africa and Spain, many natural salt lakes are dry for months, years, or even decades. By employing a number of



×30

ecological and genetic strategies, brine shrimp are able to live in these habitats as well. For all species, the ability to withstand harsh conditions, including complete and prolonged desiccation, is enhanced by the ability to produce two types of offspring. The embryos can either develop continuously into offspring capable of locomotion at birth, or development can be arrested and the embryo encapsulated, resulting in a cyst that can lie in a state of cryptobiosis, or suspended animation, for extended periods.

Since the turn of the century, the ability of brine shrimp to suspend animation has been the subject of intense study. In extreme conditions, the cysts appear to be truly ametabolic; that is, they are composed of static, nonliving cells. They do not consume oxygen at levels detectable even by today's sophisticated instruments. Recently, the world's record for cryptobiosis may have been set when oil exploration crews drilling near the Great Salt Lake retrieved cysts from sediments buried deep below the surface. Although carbon dated to be 10,000 years old, a small number of the cysts hatched when placed in water.

Research by my colleagues and me has shown that the shift from live birth to encystment is controlled by a mixture of genetic and environmental signals. With the exception of *A. tunisiana* (which produce cysts almost exclusively), brine shrimp normally produce few cysts. But when salinity rises and oxygen levels drop, as happens when lakes dry up, brine shrimp shift to the production of cysts, an ability that is shared by other organisms that live in unpredictable or ephemeral environments. Cysts remain viable after passing through the intestines of birds such as flamingos, which often migrate long distances, spreading brine shrimp from one site to another.

All species of brine shrimp are found in similar highly saline habitats: inland lakes with no drainage to the ocean (like the Great Salt Lake), or coastal salinas and commercial saltworks. But each species, and even populations within a species, does best at different temperatures and salinity levels. For example, *A. tunisiana* tolerates cold quite well and produces mostly cysts, so it is well adapted to conditions found in ephemeral inland lakes, which are usually filled with water during only the colder winter months; whereas species that give birth to live young and tolerate warm water are better suited to the commercial saltworks, because the populations there are maintained year-round, including the hot summer months. In the few places where sexual and asexual species live in the same pond (mostly in Spain), the sexual species flourish during the cool winter months, but the parthenogenetic species predominates during the summer, when salinities and temperatures are higher. The conditions found in the commercial saltworks also favor parthenogenetic brine shrimp. A single founder can colonize an unoccupied pond, and because all the shrimp are female, they all produce offspring, so that parthenogenetic brine shrimp have a very high population growth rate.

Because species are usually defined by their reproductive isolation from other species, parthenogenetic organisms present a number of taxonomic problems, and brine shrimp are no exception. Although parthenogenetic populations are found from southern Africa, throughout southern Europe, and across the midlatitudes of Asia to Japan, and vary considerably in life strategies, physiological responses, and genetic makeup, they are all grouped for convenience under the single name *A. parthenogenetica*.

About half the populations of these asexual brine shrimp are polyploid; that is, they have three or more sets of chromosomes, whereas most organisms, including humans, are diploid (with only two sets per cell). Polyploidy is very common in some plant groups but is rare in animals and usually occurs in conjunction with parthenogenesis. The extra gene copies may serve as insurance should maladaptive mutations occur or as genetic experiments that could potentially lead to new adaptations. Because they have more chromosomes than diploids, and thus

J.A.L. Cooke: Oxford Scientific Films

Brine shrimp thrive in commercial saltworks, such as the one below, near Guérande, France, where a man harvests salt from the bottom of a pond. A brine shrimp from the Great Salt Lake in Utah, right, is magnified some 30 times, revealing such fine details as the hairs on its swimming appendages.

Martyn F. Chillmaid: Oxford Scientific Films



larger cells, polyploid animals are often larger than related diploids, which may be advantageous in some conditions. In the laboratory, polyploid brine shrimp have higher numbers of offspring and longer reproductive periods than diploid individuals. Polyploids can also tolerate wider salinity and temperature ranges.

Polyploidy can also inhibit the production of new genetic variations. The numerous chrosomones in polyploids present problems during meiosis when egg cells are produced. Consequently, polyploid brine shrimp are not capable of recombination. Females produce offspring that are genetically identical to themselves, presuming no mutation occurs.

Some parthenogenetic brine shrimp, however, have only the usual two sets of chromosomes and can produce offspring that are genetically different from the parent and from each other. By employing a genetic trick known as automictic recombination, they are able to partly compensate for the absence of sexual recombination. While not producing as much genetic variability as sexual recombination, automixis reshuffles the genetic material, producing considerable variability. For example, a polyploid individual with an AB genotype can produce only AB offspring. However, a diploid AB individual capable of automixis can produce AA or BB or AB offspring. When the effect is compounded over a number of genes, a large number of genotypes, or strains, can be generated.

At Salin de Giraud, my fieldwork and laboratory studies show that such genetic recombination has produced at least sixty genotypes that vary considerably in their life strategies. For example, the number of offspring per female can vary sevenfold between genotypes, while time to maturity (a key factor in determining population growth rates) varies almost threefold. Some lineages also produce a high percentage of cysts while others produce primarily live births. Some genotypes are adapted to high-temperature, high-salinity ponds, while others specialize in cooler or less saline ponds. Despite obligate asexuality, there has been considerable evolutionary divergence among genotypes. Through automixis, asexual diploid brine shrimp can combine the principal advantage of sexuality (recombination, although in a more limited way) with the numerous advantages of parthenogenesis.

By examining enzymes and DNA (from the mitochondria) extracted from the cells of the Salin de Giraud brine shrimp, and other sexual and asexual populations, the phylogeny of the genus can be reconstructed. Although the enzymes vary considerably among the different strains at Salin de Giraud, their mitochondrial DNA is very similar. This suggests that they are all recently derived from a single ancestor. When I compared the enzymes and mitochondrial DNA of asexual populations from around the Mediterranean and Asia, however, large differences were evident, as were differences between the sexual and asexual species. This suggests that the branching of the parthenogenetic lineage from the sexual ancestral stalk was relatively ancient.

Alberto Abreu-Grobois and James Beardmore, geneticists working at University College, Swansea, Wales, estimated that the branching occurred 5.6 million years ago. Geologic evidence shows that this is the same time that the Mediterranean Sea was cut off from the Atlantic Ocean and dried up, leaving only shallow, highly saline lakes in various isolated basins—habitats that are favorable to colonization by parthenogenetic brine shrimp. If this date is accurate, asexual brine shrimp may be the oldest species that has given up sex altogether.

Despite their success in Europe, Asia, and Africa, parthenogenetic brine shrimp do not occur in the New World. My guess is that the genetic transition to parthenogenesis is complex and happens rarely. The reconstruction of the brine shrimp's phylogeny points to a single asexual branch that evolved once from a sexual ancestor, probably *A. urmiana*. In the New World, either parthenogenesis never arose in brine shrimp or asexual lineages never became successfully established.

Parthenogenesis has evolved in animals hundreds or even thousands of times, but only rarely have obligately parthenogenetic lineages survived for more than a relatively short time. Because of their inability to generate genetic variability, most asexual lineages have been considered evolutionary "dead ends," but *A. parthenogenetica* with its grab bag of genetic tricks, such as polyploidy and automixis, has forestalled its extinction. □



In Japan, a male fan-tailed warbler makes use of spider silk to hold its nest together and bind it to the surrounding reeds.

Norio Yamagata; Nature Production



Secondhand Silk

When the time comes to build a nest, many birds shop around for the finest natural materials

by Michael Hansell



The luxurious smoothness of silk has been admired for millennia, ever since the Chinese first discovered how to produce finely woven textiles from the cocoon thread of the silkworm. Even today, when factory-made, machine-washable silk shirts and dresses are commonly worn for a day's work at the office, the material retains its association with elegance.

Birds, too, have long appreciated the virtues of silk. As far as we know, however, their interest lies not in the beauty of silk but in its strength and adhesiveness, invaluable qualities in nest building. Unable to produce the impressive material themselves, many birds have long resorted to stealing from those that can.

Just how many species of birds incorporate silk into their nests is difficult to say, but the number is certainly high. I estimate that twenty-four out of forty-two families of passerine (perching) birds include species dependent on silk for nest building. In addition, nearly all the approximately 300 species of hummingbirds apparently also make use of silk in the construction of their dainty nests. (My estimate is founded on Charles Sibley and Burt Munroe's 1990 reclassification of birds, which is based on DNA-hybridization studies. This classification is somewhat controversial among ornithologists, but for my purposes—determining the number of silk-using families—it yields about the same results as do more traditional classifications.)

Birds take silk from both caterpillars and spiders. Considering that insects and spiders belong to distinctly different classes of arthropods and evolved silk quite independently, the silks they produce have a remarkably similar composition; basically, they are protein polymers, known as fibroin, composed of a limited range of amino acids.

All silk producers extrude their silk through a fine hole, sometimes described as a spigot. The shear forces resulting from the extrusion contribute to the hardening of the material to form a long, strong fiber. That, at least, is the basic picture. In practice, silk is a heterogeneous commodity, produced in different forms and with

Kathie Atkinson; Oxford Scientific Films



The eastern wood pewee of North America uses silk to secure its nest to a branch and to attach lichens to the outside, below. Silk also strengthens nest walls to better withstand the weight and pressure of wriggling hatchlings.

Robert McCaw



specialized features to suit the needs of the individual species that manufacture it.

Some caterpillars spin large amounts of silk at the end of their period of larval growth, forming a protective cocoon in which to pupate until they emerge as butterflies or moths. This silk is extruded through a pair of glands that open in the mouthparts, each through a separate spinneret. The cocoon is therefore made of a single, continuous, double-stranded thread (more than 1,000 feet long in the domesticated silkworm). In a few communal species, the caterpillars make silk through much of their larval lives, creating a silken bivouac in which they take shelter from predators, parasites, and the weather.

The situation with regard to spiders is more complicated. Spiders' spinnerets, which come in pairs, are situated on the posterior of the abdomen. The number of spinnerets varies with the species, but spiders will commonly have one to three pairs, each with several silk-spinning spigots. Consequently, a spider can produce different kinds of silk. A female, for example, might employ two types just in the making of a cocoon to protect her eggs: fine and soft for the inner layer; coarser for the outside.

The same spider may also build a web to capture prey, which may require yet other kinds of silk. Some webs are sheets or tangles of threads that delay the escape of prey, allowing the spider, alerted by vibrations that travel through the threads, time to make its way over to the entangled victim and deliver the *coup de grâce*. Many spiders have a more sophisticated design in which a silk scaffolding supports specialized, sticky capture threads. But (and this is the last complication) spiders have evolved two different kinds of sticky thread: cribellate and ecribellate.

Cribellate spiders have a sort of sievelike plate, just in front of the paired spinnerets, with hundreds of fine spigots. A mist of fine thread, teased out of this cribellum by combs on the spiders' hind pair of legs, is laid on two axial strands produced by the posterior pair of spinnerets. Yet another kind of silk may be used to glue this cribellar material to the axial threads.

The capture principle in this case appears to be mainly that the hairs and spines of insects become ensnared in the fine tangle of cribellar threads. Ingenious, a bit complicated, and perhaps rather extravagant on silk production, but because the threads retain their stickiness, this approach is useful for relatively immobile spiders that build up sheet webs.

Enter the ecribellate spiders, stars of the spider world with their elegant engineering, typified by the orb web, a radial array of support threads on which is laid a spiral capture thread. The essential feature of this capture thread is a string of beadlike, sticky droplets laid on a strong pair of core threads. A potential drawback of this system is that the droplets dry out, quickly losing their stickiness. However, so effective are the droplets when still moist, and so readily and economically can the webs be assembled, dismantled, eaten, and recycled (often in just one night) that these webs are highly efficient, particularly for mobile spiders.

In addition to varying in stickiness, silk comes in different thicknesses. A typical radial thread of an ecribellate orb web is about 5 microns (a micron is a thousandth



Thanks to the strength and stickiness of silk, this yellow-breasted sunbird, left, can begin to construct a nest on a few thin twigs at the end of a branch. The long-tailed hermit hummingbird from Peru, below, virtually swaddles its tiny nest in silk and uses still more to anchor the nest to a leaf.

Gunter Ziesler; Peter Arnold



of a millimeter). The diameter of the fine capture threads of cribellate spiders is less than 0.05 microns, while the coarse outer threads of some spider cocoons are a massive 50 or so microns. That size range is roughly comparable to that between a hair on your head and a rope used to secure an ocean liner.

Even the thickest of silk, of course, is pretty thin stuff. But, as the Chinese discovered long ago with the silkworm caterpillar, if you can gather enough of the material, it is a valuable commodity indeed. (There is a Chinese legend that in about 140 B.C., mulberry seeds and silkworm eggs were concealed inside the headdress of a betrothed princess and smuggled from one part of China to another. According to this story, silk production was valued enough to become an essential, if secret, part of the business end of the marriage arrangement.) For birds, the guidelines for silk use would appear to be similar: to be truly useful, silk must be available in reasonably sized loads.

In some parts of the world, notably the tropics, birds that use silk are abundant. But in Britain, where I live and work, there are relatively few. The chaffinch, a common garden and woodland species, is one of them. Two years ago, I asked Nick Storer, a graduate student of mine, to find out more about this thieving dependency. He discovered that 92 percent of the nests he examined contained at least some spider silk and that after moss, it was the second most frequently used building material. The greater part of this silk was from spider cocoons; what web silk there was came from the only cribellate spider in the area. This finding surprised us since the sticky orb webs of ecribellate spiders were as readily available.

So the chaffinches are being selective, but what is the basis of their choice? It could be silk volume. Orb web builders are parsimonious in their use of silk, just the kind of trait that could make their webs unattractive to birds.

Cribellate silk may also simply be more effective. The sticky droplets of ecribellate silk can be likened to Scotch tape, which, having been stuck down, cannot be easily peeled off and reused. Cribellate silk works differently, according to the Velcro principle. Its fine threads come in a useful assortment of tangles and loops, which the birds can use to catch hold of leaf edges and other nest materials and link them together. And like Velcro, this kind of silk can be repeatedly adjusted during nest building without losing its effectiveness. Later on in the season, as the nest becomes more chick nursery than egg cup, running repairs are possible, too.

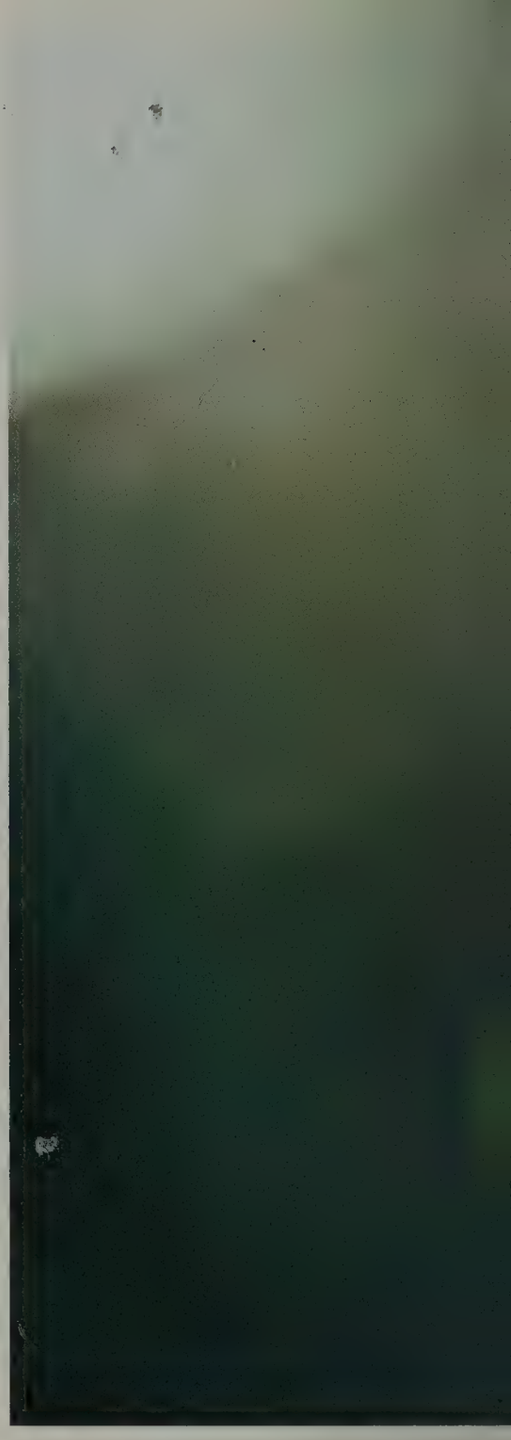
Spider cocoon silk can be worked in much the same way and offers the additional advantage of sometimes being available in sizable packages. A whole cocoon torn from a window frame, for example, provides a lot of silk for a minimal effort.

Of course, most nests, even conventional cup-shaped nests, are often a mix of styles and materials. The nest of a chaffinch, for example, has a mossy wall; feathers, hair, and plant down line the inside of this wall. The birds use silk in several ways. Some is worked into the outer part of the mossy wall, giving it strength. More is used to attach a layer of lichen to the outside wall, a job for which cocoon silk is particularly favored. And additional pieces of silk are used to anchor the nest in position. Chaffinch nests are generally well supported below and at the sides by small twigs, but the silk provides additional security.

The chaffinch's technique of nest attachment pales in comparison with the sophisticated arrangements of some tropical species. Most silk-using birds inhabit tropical and subtropical woodlands and forests, where predators—such as tree-climbing monkeys and snakes—abound. One result of this pressure from predators has been to push nests more and more toward tree extremities, where there is less traffic or where predators simply cannot reach.

Securing a nest in such sites poses challenging engineering problems: how to keep a nest from tumbling off a narrow branch, for example, especially once it is burdened with the weight of eggs and an incubating parent. The solution: lash a lot of silk around the base of the cup to attach it to the branch. Now what to do when the chicks hatch and begin pressing against

H. Beste; AUSCAPE International



The Asian paradise flycatcher, below, dots its nest with patches of silk and other reflective white objects. The contrasting plumage of the Australian frilled monarch, right, together with patches on the nest, may help break up the bird's outline as it sits on the nest.

Gertrud and Helmut Denzau



the walls of the cup, threatening to burst it. Again, silk—bound round the nest like hoops around a barrel or completely glazing the cup—is the answer.

Oriental and Australian fantails and many hummingbirds solve their construction problems this way, but some other birds prefer to hang their nests and thus need support from above, not below. Silk can handle these situations, too, for what is a spider web if not a piece of hanging architecture? And what is a hanging nest if not a hammock? At least six bird families have arrived independently at this solution. Commonly, the nest is nestled in the horizontal fork of a branch, attached to the angled twigs at the rim, usually by strands of vegetation plus silk, sometimes by silk alone. Examples of such hammocks are found among New World flycatchers and vireos, Oriental and Australian drongos, and Old World white-eyes.

So how much further can the birds go? Well, for a nest in a tree, the end of the line is the leaf itself; with the aid of silk, many birds have proved equal to the challenge of securing a nest even there. The rufous-breasted hermit hummingbird, for example, places a fragile cup of fine woody stems on the underside of a drooping fern frond or palm leaf, lashed into position with encircling silk.

The tailorbird of India uses plant-down fibers and spider cocoon silk to stitch together a purse of green leaves; inside the purse, the bird builds a grassy cup. The gray-crowned prinia, also of India, stitches a leaf purse nest so like that of the tailorbird it is difficult to tell them apart. According to Sibley and Munroe, the prinia and the tailorbird belong to separate families, which raises the possibility that silk stitching evolved more than once in birds.

One of the most unusual uses of silk in nest construction is the work of the little spiderhunter. A type of sunbird (Old World equivalent of a hummingbird), the little spiderhunter suspends its nest underneath a leaf, using a technique familiar to sheet-metal workers—the pop rivet. To secure one sheet of metal to another, sheet-metal workers whack a rivet through the sheets, and once the rivet's head is on the other side, it spreads out and cannot be withdrawn.

I hypothesize that to achieve a similar result, the little spiderhunter hangs underneath the leaf, holding a silk thread, on the end of which it has somehow created a rounded knob. Then, I believe, the bird, holding the knob inside its beak, strikes the leaf, simultaneously pushing the knob through the hole with its tongue. As the beak recoils, the leaf's natural elasticity causes the hole to shrink, trapping the silken head by the "neck." With scores of such thread supports, a nest can be hung below a leaf like a snug gondola. One nest in my collection has some 150 pop rivets, seemingly made of caterpillar silk.

Silk, then, often proves invaluable in holding a nest together or in place; I think it may also sometimes help hide the nest from possible predators. The chaffinch, for example, employs silk to attach a cover of lichens to the mossy cup of its nest. I believe it does so because a ball of moss in a tree might look rather conspicuous, while the lichen—a common covering on branches in chaffinch habitat—might lend a bit of treelike verisimilitude to the nest. However, this may not be the whole story.

I have now looked at quite a large number of nests in museum collections and have become aware that lichen coverings are very pale. Many of these nests, of course, are old, sent in by colonial civil servants and travelers decades ago. So one possibility is that these nests have just faded. More and more, however, I have come to think that is not the case, at least not always. Some nests, I believe, may be designed to resemble "ghosts."

The cup nest of a paradise flycatcher that I examined, for instance, was covered with creamy flakes of lichen interspersed with whole white spider cocoons. The entire exterior of another nest, that of a small sunbird, was covered with membranous white spider cocoons. To me, these coverings, and others like them, seemed designed to be pale. My suspicions were reinforced last summer when I obtained nearly thirty freshly used nests of the long-



tailed tit, a European relative of the chickadee. These tits use hundreds of woolly, dull-colored spider cocoons to hold their globular, mossy nests together. They then carefully cover the nest with a pale layer consisting of hundreds of separate pieces of lichen and, usually, dozens of membranous white spider cocoons. This species frequently places its nest among small branches that bear no lichens, so the goal of all this work cannot be simple camouflage. An additional surprise was that some of the nests included pieces of white styrofoam and one had pieces of newspaper in the outer nest covering. I suggest that the strongly light-reflecting surface of these nests may have made them harder to see and recognize as a nest, in some cases perhaps making them almost invisible.

A different, but related, technique may be employed by some Australian monarch species. These birds suspend their nests precariously among fine twigs, but instead of covering the nests with a pale, reflective layer of lichens and silk, they bejewel them with an irregular scattering of white patches. Thanks to the irregularity, shafts of light appear to pass straight through the nest, so that it may appear more like a lump of vegetation with holes in it than a working nest. Fanciful? Maybe, but the nests of a number of bird species, such as pigeons and doves, are indeed insubstantial and the light does pass through them. This kind of construction could also, of course, be designed to get around other problems, such as flooding. At the moment, we are still speculating, but I look forward to uncovering the explanation for these and other intriguing aspects of silk use on bird nests.

Many questions now seem worth investigating. How specialized are the relationships between silk-stealing birds and providers? Is the habitat range of any bird species limited by the amount of usable silk in the habitat, or its breeding period by the life cycle of spiders? And what about the unfortunate spiders? Is their biology seriously affected by the depredations of nest-building birds? What is the relationship between the size of birds and their dependence, if any, on silk?

I have taken a step toward answering this last question. The Sibley and Munroe reclassification has created an enlarged family of crows and their relatives, the Corvidae. The crows themselves are quite large birds, but according to Sibley and Munroe, the family now includes much smaller species, such as fantails and monarchs. I have looked at silk use in relation to both the dry weight of the nest and the

diameter of its cup (a reasonable indication of the sort of load a nest has to bear). My results confirm what I had expected: small birds are using silk. What I did not expect was the sharpness of the cut-off between birds for which silk can be considered very useful and those for which it is of no use at all. In the Corvidae, nests weighing one ounce or having a cup diameter of three inches or less, such as those of the small slaty monarch, are commonly dependent on silk. Any heavier or larger nests appear to contain no silk.

How widely this relationship and these figures apply to other bird families remains to be seen, but I was pleased to find confirmation of the general size relationship among weaverbirds. These birds of Africa and Asia are best known for the basketry skills evident in their elegant covered nests and specifically for the lack of any "glue," either to hold the nest together or to suspend it from the branch. My nest examinations revealed that indeed there was no silk at all in the larger weaverbird nests (for example, the two-ounce nest of weavers and the three and a half ounce nest of the malimbes); however, in the smaller, half-ounce, domed nest of the red fody—also placed in the weaverbird subfamily by Sibley and Munroe, as well as by traditional taxonomists—I found significant amounts of silk.

Two possible explanations come to mind for this relationship between nest size and silk use. The first is that in larger nests, silk is not equal to the mechanical demands, but as fly fishers old enough to remember using silk fishing line will confirm, this insect silk can take a lot of stress. The second explanation, and the one I favor, is based on economics: larger birds would need more silk than they could conceivably gather without taking up time and energy required for other aspects of their lives. Even for small birds, gathering silk may be a time-consuming task. But I believe their efforts are amply rewarded. Pinching silk has allowed some birds to greatly expand their possible range of nest sites and—perhaps—devise new methods of concealment. □

As light bounces off the silk-covered nest of a scarlet-breasted sunbird from Nigeria, it may make the nest appear more like a "ghost" than a solid structure, thus deceiving potential predators.
P. Ward; Bruce Coleman, Inc.





How Did Humans Get That Way?
The second in a two-part series of articles on the emergence of modern humans, presented in conjunction with the April opening of the Hall of Human Biology and Evolution at the American Museum of Natural History.

The Pulse That Produced Us

Two major global coolings may have prodded antelopes and humans to evolve

by Elisabeth S. Vrba

Earth's crust and atmosphere change constantly, and wedged in between them like a sandwich filling, life evolves as well. To what extent are extinction and speciation—the evolution of new species out of ancestral populations—tied to geophysical changes? Did humans originate in response to some identifiable cosmic or climatic event?

Charles Darwin, in an 1838 notebook, noted that "man is a species produced like any other—lawfully." To learn more about our own origins, I have looked for evolutionary patterns in other organisms that lived at the dawn of humanity. Antelopes are good animals to examine for clues because they are reliable indicators of past environments and shared the African savanna with our early ancestors, the australopithecines, or man-apes. Conveniently, antelopes make up 60 to 80 percent of all large mammal fossils found in the same strata as hominids, the family of primates that includes australopithecines and humans.

About twenty years ago, as a South African paleontologist studying the Transvaal's limestone caves, I first noticed that



Until about five million years ago, vast tropical rain forests, like this one in Zaire, probably covered much of the African continent.
Frans Lanting; Minden Pictures

Joe McDonald



Wildebeests, or gnus, below, still thrive in the African savannas. Modern species first appeared during the extension of dry grasslands, about 2.5 million years ago. Gemsbok, in the genus Oryx, *right, can graze for hours in blazing sun on the open plains. When this desert-adapted antelope pants, a special venous network cools the blood entering its brain.*

Frans Lanting; Minden Pictures





somewhere in the fossil deposits between 2.5 million and 2 million years ago, antelopes and other animals changed strikingly. Anatomical features such as teeth indicated that antelopes living before 2.5 million years ago had occupied moist woodlands. Shortly afterward, however, these forest antelopes disappeared and were replaced by many new species that graze only in dry, open savannas.

But because the Transvaal cave strata were jumbles of washed-in bones, the sequence was not reliable and had to be dated by being compared with deposits elsewhere. Some years later, in East Africa, other researchers found similar fossils in deposits that could be dated by radiometric techniques. Several independent studies have since confirmed that the same kind of faunal change that took place in South Africa also occurred in Ethiopia, Kenya, and Tanzania close to 2.5 million years ago.

Such a dramatic change in large fauna, and by inference in vegetation, is one line of evidence that southern Africa became significantly drier about 2.5 million years ago. I wondered if this was a purely local phenomenon and whether the change was slow or rapid. A 1980s study of deep-sea cores near Greenland by Nick Shackleton, of Cambridge University, contributed some answers. Shackleton discovered abundant evidence for an extensive arctic glaciation dated close to 2.5 million years ago.

During that period, global temperatures may have plummeted by as much as 10° to 20° F, and the world became colder than at any time in the past 65 million years. The continents became



much more arid, and the steppes advanced toward the equator. The earliest fossils of *Oryx,* the most arid-adapted antelopes of all, appeared along with other grazers of open savannas, such as the giant buffaloes *Pelorovis* and giant hartebeests *Megalotragus.* These species soon extended their ranges from southern and eastern Africa toward the equator, where we find fossil testimony of their presence. Steppe and grassland horses, *Equus,* from Europe moved east into India and Pakistan. They also migrated south into Africa, together with Asian forms like the Indian black buck, *Antilope cervicapra,* but while the horses evolved into several varieties of zebras, the Asian antelopes did not last long in Africa.

A similar, earlier cooling also seemed to affect all of sub-Saharan Africa about 5 million years ago, close to the Miocene–Pliocene boundary. Climatologists John Mercer and James Kennett and paleoanthropologist C. K. Brain have documented marked swings in the global climate at that time, with widespread continental cooling and the lowering and retreat of oceans. We also know that the Mediterranean dried up, leaving massive salt deposits, and that thousands of miles of savannas opened up at the expense of forests on several continents. This earlier cooling also produced waves of extinctions and radiations of species, giving rise to the seven major groups of antelopes that still dominate the African savannas today. Within these groups, however, many species went extinct at the later cooling 2.5 million years ago.

How did our primate ancestors fare during these climatic changes in South Africa? About 5 million years ago, the first proliferation of antelope species coincided with the occurrence of the first australopithecines in East Africa—perhaps their first appearance on the planet. Before that time, large primates were apish forest dwellers that shared their leafy refuges with ancestral antelopes. In between the 5-million-year-old deposits and those 2.5 million years old, the only known hominids are the lightly built australopithecines, five-foot-tall, bipedal primates with ape-sized brains and upright posture. After 2.5 million years ago, however, we see evidence of an explosive radiation among hominids. Apparently several different species appeared; paleoanthropologists are still arguing about how many. Clark Howell, of the University of California at Berkeley, for instance, thinks there were five or six. Among them were the large, vegetarian man-ape *Paranthropus* and various members of the human genus, *Homo*—who thrived with the further spread of dry grasslands and the continued shrinking of forest habitats. Other evidence of new kinds of hominids include the first-known robust australopithecine fossil, the Black Skull, found by



Unlike other post-Miocene antelopes, impala must drink often to avoid dehydration. They have not changed in five million years—during which time the entire human lineage evolved.
Frans Lanting; Minden Pictures

Richard Leakey and Alan Walker near Kenya's Lake Turkana (*see* page 52) and the oldest-known fragment of a *Homo* species, from Lake Beringo, Kenya, dated by Andrew Hill's group at Yale to 2.5 million years ago.

The archeological record of artifacts offers additional corroboration of dramatic change. Stone tools from Ethiopia—the earliest yet discovered—date to between 2.4 and 2.6 million years ago. Using tools to obtain and prepare food was an important innovation for hominids and indicates increased brain size and function.

The British ecologist Evelyn Hutchinson once referred to the "evolutionary theater and the ecological play." Halfway through the hominid play that began 5 million years ago, something happened that pushed most of the old cast members (including the small-bodied australopithecines) off the stage and introduced new ones (such as *Homo* species)—a process I call turnover-pulse. I believe that when we better understand the events at the Miocene–Pliocene boundary, we will find that the appearance of the australopithecines was only one part of a global turnover of species, one of the recurrent pulses in the history of life.

New species of primates, antelopes, birds, and carnivores may all have originated in response to several successive cooling plunges during the later Miocene. Many African lineages survived the climatic changes intact, but those that underwent extinctions and speciations appear to have done so in concert with others: plants, hominoids, antelopes, rodents, and such marine invertebrates as snails and foraminifera. All the evidence, as I see it, indicates that the lineage of upright primates known as australopithecines, the first hominids, was one of the founding groups of the great African savanna biota.

My hypothesis that the same climatic pulses dramatically stimulated both antelope and human evolution has increasingly gained support from specialists studying many disparate creatures. A decade ago, paleontologist Hank Wesselman discovered a rapid pulse of extinctions and speciations in African rodents at the 2.5-million-year mark. In addition, Raymonde Bonefille, of Marseille, has found that pollens in Ethiopa show that there was a simultaneous "turnover" of many plant species. In each case, the pattern is wholly consistent with global cooling, increased glaciation, a shrinking of wet, forested country, and the rise of vast, dry grasslands. Animal species everywhere either moved, bowed out, or evolved into new groups, as Italian paleontologist Augusto Azzaroli has demonstrated for many lineages of Eurasian mammals, including deer, cattle, various carnivores, and rodents.

According to the classic Darwinian view, the "engine" that drives the evolution of species is competition between organisms; extinctions occur when species outcompete others for the same resources. If one were to represent each species as a star that lights up in the sky, the Darwinian model would show some stars appearing and others going dark in a fairly random pattern. But the fossil record appears to tell a different tale. Species seem to arise and vanish in pulses of varying intensities, with many appearing and others disappearing at the same time. Some of



these pulses would appear to be dim, while others would light up the heavens.

As a rain forest or grassland shifts or disappears, diminishing animal populations can remain unchanged within the shrinking habitats in which they evolved, perhaps expanding again when and if a favorable climate returns. On the other hand, if conditions are right, evolution within the threatened population may produce a new species. According to the scenario first proposed by Harvard biologist Ernst Mayr in the 1940s, an animal species may occupy an extensive geographic range until major changes in rainfall, temperature, or geographical boundaries break the population into smaller, isolated groups. These "island populations" cease to trade genes, and eventually some may diverge sufficiently to form the cores of new species. Without the impetus of environmental pulses, most species and ecosystems seem to remain in equilibrium most of the time and resist change until they are pushed.

I see the biosphere as a living layer, stretched thinly over the globe, responding rhythmically to the beat of the earth. During a climatic shift, species may either find some safety as generalists, able to tolerate a wide range of foods and conditions, or they may cling unchanged to the shrinking habitats in which they evolved. In the long run, however, both of these strategies may lead to dead ends. If a lineage's evolutionary success is measured by the production of many diverse species, then the successful gamblers on speciation are the big winners. Our ancestral species, the early australopithecines, entered a narrow genetic corridor about 2.5 million years ago. They disappeared, but as the progenitors of novelty—ultimately including the most ubiquitous large mammal species on earth—they hit the jackpot. □

A Skull to Chew On



A cranium from northern Kenya forces some rethinking of the human family tree

by Donald C. Johanson

The Black Skull (or KNM-WT 17000, as it is formally called) was recovered in the summer of 1985, in the desolate wastes west of Africa's Lake Turkana, where it was first identified by Alan Walker, of Johns Hopkins University. The skull—more properly a cranium because the mandible is missing—has been stained blue black by manganese-rich minerals. It has cheekbones like stout flying buttresses, a projecting face, and a swept-back braincase with a prominent longitudinal (or sagittal) crest, presenting an overall architecture reminiscent of a Boeing blueprint. The *International Herald Tribune* called it "the 'most exciting' discovery in the evolution of early man in years." Nevertheless, the truth is that it represents a dead end on the tree of human evolution. So why all the fuss about a creature that wasn't even our ancestor?

When I first laid eyes on a cast of the Black Skull, I was immediately impressed by its mixture of advanced and primitive traits. By advanced traits I don't mean more humanlike ones but simply specialized characteristics, indicating that the anatomy has diverged from the ancestral condition. On the one hand, the projecting face, very small cranial capacity, cresting pattern on the rear of the cranium, and a host of other features recall the more ancient species *Australopithecus afarensis,* which includes the well-known skeleton Lucy. On the other hand, the prominent sagittal crest, the dish-shaped (flat, concave) face, and enormous molars and premolars (inferred from the large tooth roots) are typical of later creatures known as robust australopithecines.

With their massive jaws, greatly enlarged chewing muscles, and huge crushing and grinding cheek teeth, the robust australopithecines were once successful members of the hominid family—the group that includes humans and their extinct close relatives. Their distinctive cranial architecture was forged by natural selection to process a tough, fibrous, vegetarian diet. Robert Broom first recognized this adaptation in fossils from South Africa, which he christened *Paranthropus robustus,* meaning a "robust near relative of man." In 1959, Mary Leakey found an East African version at Olduvai Gorge that was first named *Zinjanthropus boisei* by Louis Leakey. (*Zinj* derives from an Arabic word that means "East Africa," and *boisei* honors Charles Boise, who financed the work at Olduvai.) Most anthropologists now lump these two species in the genus *Australopithecus,* but there is an increasing tendency to use Broom's genus, *Paranthropus.*

When Frank Brown, of the University of Utah, a recognized expert on the geology of the Lake Turkana Basin, reported an age of roughly 2.5 million years for the Black Skull, there were lots of raised eyebrows in the anthropological community. Hominid fossils in East Africa from between 2 and 3 million years ago are exceedingly rare, so the Black Skull was a welcome addition to the fossil record. At the same time, it called into question many people's pet theories concerning the timing and manner of change in hominid evolution.

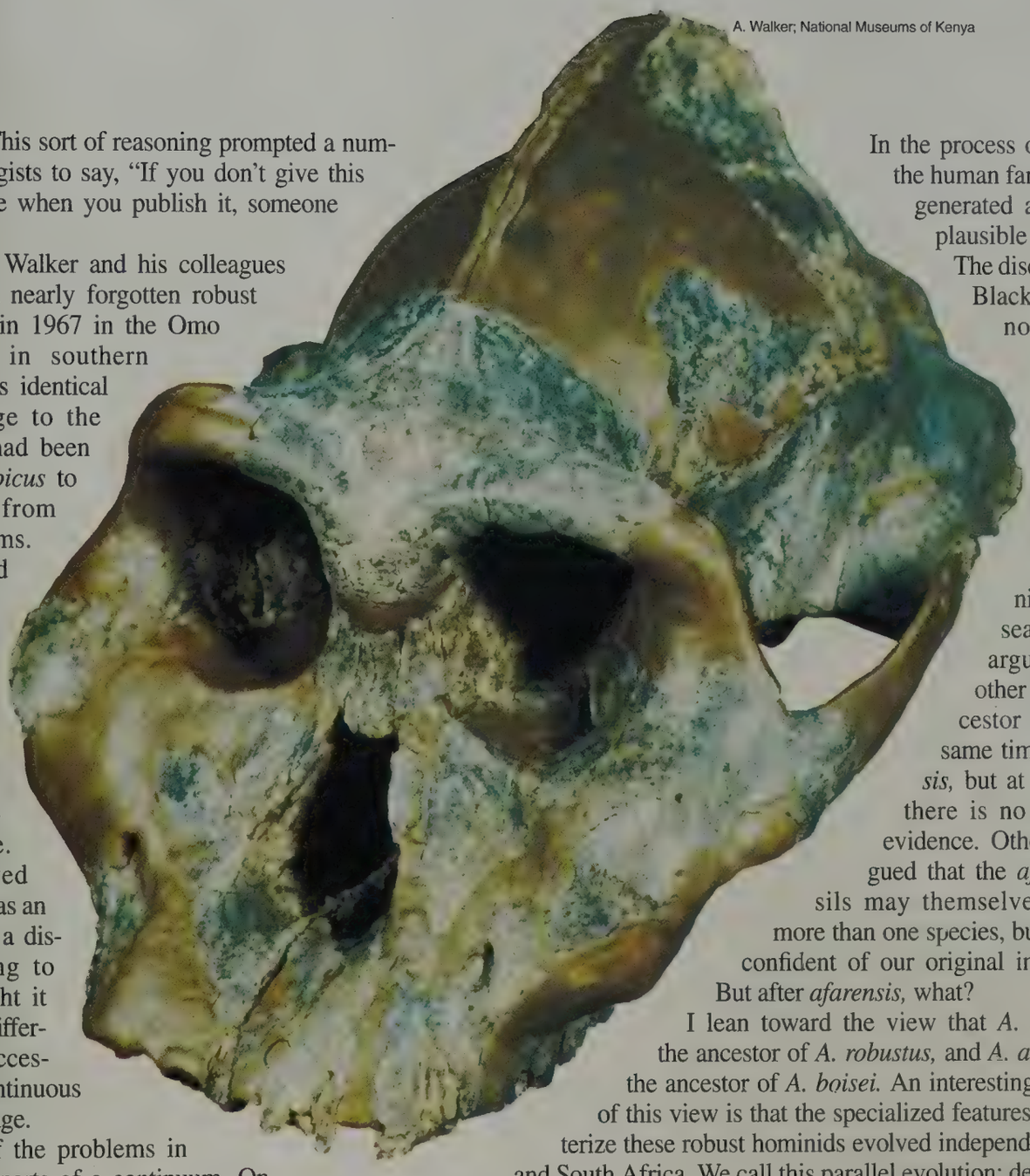
In 1979, Tim White, my colleague at the University of California, Berkeley, and I had proposed a version of the human family tree in which we placed *A. afarensis,* at 3.5 to 3 million years ago, at the base of a simple Y pattern. We considered it to be the primitive, generalized species ancestral to both the robust australopithecines and the genus *Homo* (the line culminating in modern humans). There was a limited choice of fossils to guide us in the interval between late *A. afarensis* and the good samples of fossil hominids a million years later. Perhaps the most controversial aspect of our tree was how we treated *A. africanus,* a "gracile" australopithecine species discovered by Raymond Dart in South Africa and dated between *A. afarensis* and the robust australopithecines. Others considered this fossil species to be, if anything, on the line leading to *Homo,* but we saw it as ancestral exclusively to the robust australopithecines. In my opinion, *A. africanus,* with its heavily buttressed mandible and expanded chewing teeth, forecasts the vegetarian specialization of the robust forms.

At that time we placed all the robust types in a single species, but the East African vegetarians have a distinctive facial anatomy, as well as larger cheek teeth and stronger cresting patterns than their South African relatives. They are sometimes called hyperrobust. Yoel Rak, of Tel Aviv University, subsequently convinced us we should therefore distinguish two species—*A. robustus* in South Africa and *A. boisei* in East Africa.

This is the way things stood until the Black Skull appeared, forcing anthropologists to go back to the blackboard and draw some new family trees. The first task was to establish the relationship of the Black Skull to the other robust types. To resolve this, Walker and his colleagues looked at the degree of anatomical resemblance of forty features common to the Black Skull and other species of *Australopithecus.* This is standard procedure—the more traits that are shared between any two species, the more trust we have that there is a close evolutionary relationship between them. This exercise led Walker and his colleagues to conclude that "for most of the features the new specimen resembles *A. boisei.*"

Using that list as a guide, Bill Kimbel, of the Institute of Human Origins, Tim White, and I embarked on a similar exercise incorporating thirty-two cranial features (some were also on Walker's list, but we added a few and combined those we felt were redundant). In some respects our conclusions were similar. Since twelve of the traits of the Black Skull were shared with both *boisei* and *robustus* (and not with other hominids), the robust nature of the skull was certain. But we felt it could not be tied exclusively to either species: of the remaining traits, the Black Skull shared only two exclusively with *boisei.* What most surprised us was the close relationship between the Black Skull and *afarensis*: they shared a total of twelve of the remaining traits.

The Black Skull thus seemed to us a potential evolutionary link between *afarensis* and the later *robustus* and *boisei.* The timing was also right—at 2.5 million years, the Black Skull was also intermediate in age. Calling it *afarensis* would obscure the evolutionary importance of the enigmatic cranium as much as



A. Walker; National Museums of Kenya

calling it *boisei.* This sort of reasoning prompted a number of anthropologists to say, "If you don't give this thing a new name when you publish it, someone else will."

In their paper, Walker and his colleagues had referred to a nearly forgotten robust mandible, found in 1967 in the Omo River deposits in southern Ethiopia, that was identical in geological age to the Black Skull. It had been named *A. aethiopicus* to distinguish it from other robust forms. They suggested that if future finds justified a species distinction for the Black Skull, then the name *A. aethiopicus* would be the appropriate choice. But they believed the Black Skull was an early member of a distinct line leading to *boisei* and thought it unwise to give different names to successive parts of a continuous evolutionary lineage.

This is one of the problems in naming different parts of a continuum. On the scale from black to white, there are innumerable shades of gray, but at the ends of the scale, black and white are very distinct. Walker and his associates saw the Black Skull and *boisei* as two shades of gray. But we saw the differences as black and white, and so went with the designation *A. aethiopicus.* Although any tie between the toothless old mandible from Ethiopia and the new cranium is at best tenuous, most anthropologists appear satisfied with this decision. To be sure, when intermediates are recognized between *aethiopicus* and *boisei,* this distinction will become less clear.

The evolutionary implications of the Black Skull are far more important than the nomenclature debates. KNM-WT 17000 is the oldest robust fossil ever found. This means it could be ancestral to *boisei* or *robustus* or possibly both. Even more important, the South African *A. africanus* lacks the primitive features shared by *afarensis* and *aethiopicus* and can no longer be considered an ancestor to all the robust forms.

In the process of redrawing the human family tree, we generated a number of plausible hypotheses. The discovery of the Black Skull does not alter the position of *A. afarensis* as the last common ancestor of all the later hominids. Some researchers have argued that another hominid ancestor lived at the same time as *afarensis,* but at the moment there is no convincing evidence. Others have argued that the *afarensis* fossils may themselves represent more than one species, but we remain confident of our original interpretation.

But after *afarensis,* what?

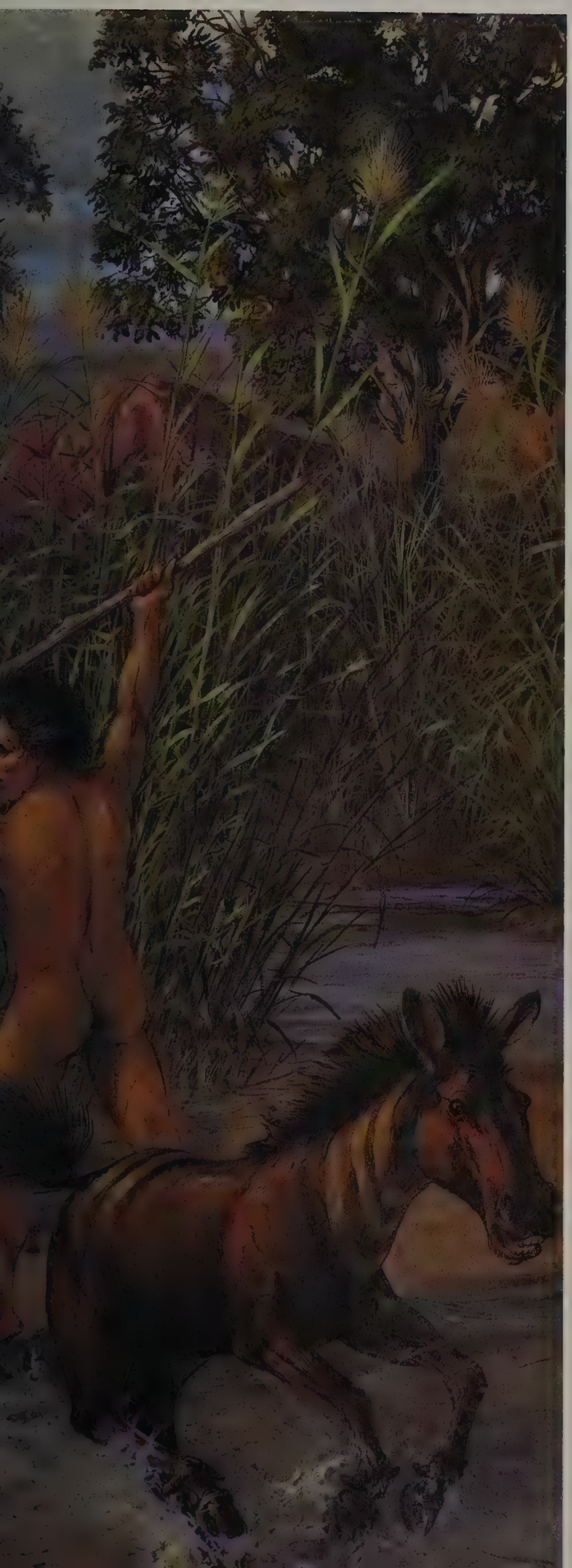
I lean toward the view that *A. africanus* is the ancestor of *A. robustus,* and *A. aethiopicus* is the ancestor of *A. boisei.* An interesting implication of this view is that the specialized features that characterize these robust hominids evolved independently in East and South Africa. We call this parallel evolution: descendants of a common ancestor diverge and subsequently evolve similar adaptations independently.

The development of a robust, vegetarian specialization was a viable hominid adaptation. Although we are not certain exactly when our robust relatives died out, the last of their fossils date to about 1.2 million years ago in East Africa, while those in South Africa may be slightly younger than 1 million years old. In terms of our existence, it is humbling to think that they survived for more than 1.5 million years and still went extinct. If, as I believe, the robust adaptation arose twice, then both times it met with extinction.

Most monkeys and apes are plant eaters. The vegetarian specialization of our robust relatives was a continuation of a long-standing dietary adaptation and feeding strategy among hundreds of species of primates. Perhaps the real lesson we can learn from the Black Skull is the reminder that we, *Homo sapiens,* are clinging to a side branch of the primate family tree. □

In an artist's reconstruction of the Nihewan Basin one million years ago, a band of Homo erectus *ambush three-toed horses that have come to drink from a freshwater stream.*
Michael Rothman





Ancient Asia's Cutting Edge

A prehistoric Chinese lakeshore yields the imprint of early humans

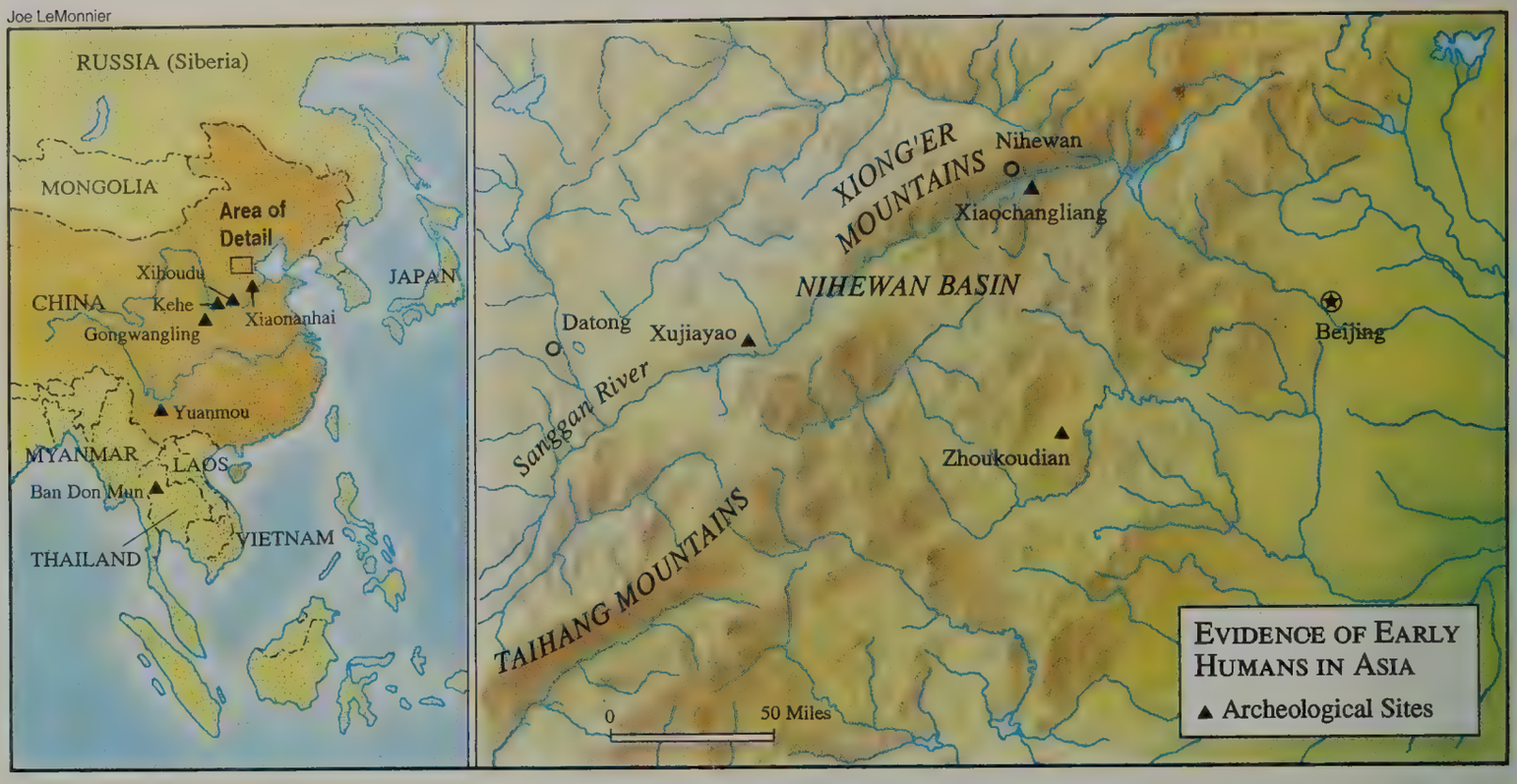
by Geoffrey G. Pope

"The Nihewan welcomes you and heaven smiles," Wei Qi exclaimed as we stood on the rim of northern China's Nihewan Basin, gazing down at the shiny ribbon of the Sanggan River. Far to the west, orange clouds of sulfurous coal smoke marked the industrialized, ancient town of Datong, but here the air was fresh and brilliantly clear. No tempestuous summer squalls or dust storms threatened to obscure the vista of plunging gorges and multicolored layer-cake cliffs that stretched to the mountainous horizon. The weather was perfect for pursuing the early traces of human ancestors in Asia.

Wei Qi's self-chosen name means Strange Guard, but the local people, after watching his often solitary, meagerly financed surveys and excavations among the treacherous canyons for fifteen years, have bestowed on him the affectionately mocking title of Emperor of Nihewan. In China you cannot go anywhere without seeing people, and in the Nihewan, Wei Qi knows them all. Farmers are usually the first to alert him to new locations where fossils or archeological materials are exposed on the eroding flanks of the valley.

The locale first attracted the attention of Western paleontologists nearly seventy years ago, when fossils of a large number of extinct mammals were discovered near Nihewan, a village in the northeastern end of the basin whose name means "muddy bend in the river." The fossils included rhinoceroses, three-toed horses, bison, saber-toothed cats, hyenas, and wild dogs. Many scholars felt confident that the area's red clays and calcareous silts would one day yield the earliest remains of human ancestors in China. During the years of China's isolation, between the Japanese invasion in 1937 and the new "open door" policy, a few Chinese archeologists continued to pursue that dream. Human fossils have not yet come to light, but in the late 1970s and early 1980s Chinese paleontologists and geologists finally discovered unequivocal archeological sites containing early stone tools. With the easing of international tensions, in June of 1988 I was fortunate enough to be the first Westerner to sample and survey in detail the Nihewan's caches of artifacts and animal fossils.

From the southeastern rim of the basin, Wei Qi led our descent down a series of ridges toward the wind-raked promontory of Xiaochangliang, where researchers had turned up artifacts



among the gray and white silts of an ancient lakeshore. The donkey path to the site is generally less than a foot wide, and on either side the slopes are so steep that not even the resourceful farmers have managed to plant anything. (During World War II, the Japanese army attempted to occupy this rugged terrain, only to discover that a single-file patrol of well-equipped soldiers was no match for even the most modestly armed peasant.)

When we arrived at Xiaochangliang, I crouched down to inspect the blazing white ground. I soon saw that the walls and floors of the test pits contained not only a profusion of stone flakes and the cores from which the early toolmakers had struck them but also fossil animal bones, some of them betraying cut marks. Taken together, these were the earmarks of a workshop or possibly a campsite, undoubtedly occupied by *Homo erectus,* a species of early human that had originated in Africa and spread to Asia about one million years ago. Subsequent results from three different laboratories indicate that the earliest of these deposits are at least 700,000 years old. Based on stratigraphy and the presence of certain extinct mammals, I believe they may be one million years old.

Open-air campsites of this age represent a rare find, for other, similar sites in China have proved to be merely natural accumulations—places where artifacts and the remains of extinct animals were deposited together not as the result of human activity but by flowing water, sediment accumulation, or other environmental or geological forces. The earliest such sites are Xihoudu, Kehe, and Gongwangling, also in northern China, and Yuanmou in the south, all perhaps older than a million years. In Southeast Asia, the site of Ban Don Mun, Thailand, where I have worked, is well dated at more than 700,000 years. But none of these provide the archeological "photograph" of daily life that paleoanthropologists seek.

Until Nihewan, the only clearly occupied early sites in Asia were caves, notably those at Zhoukoudian, the home of Peking man. Just sixty-five miles to the southeast of the Nihewan Basin, Zhoukoudian contains ample evidence of the diet, culture, and anatomy of *H. erectus* between 500,000 and 200,000 years ago. (For comparison, in East Africa the open-air occupied sites of Olduvai Gorge, Lake Turkana, and the Omo Basin have enabled scholars to reconstruct the activities of *H. erectus* and that species' predecessor, *H. habilis,* up to 2.3 million years ago.)

The Nihewan Basin is located at the northeastern edge of China's great loess plateau. Loess is the sediment made up of the yellow dust that has been raining down on northern China (and many other regions of the world) for more than 2.5 million years. The Chinese loess probably originated in Mongolia and Siberia, most likely from the scouring of bedrock by periodic ice age glaciers. This fine-grained, angular dust colors China's mightiest river, the Huang He, or Yellow River (*see* "Lash of the Dragon," *Natural History,* August 1991).

The windblown loess forms a relatively shallow cap on top of the sands, silts, and clays of the Nihewan Basin, which are ancient river, stream, and lake deposits. Fortunately, the stream and lake sediments were apparently created by relatively gentle water action, increasing the chances that ancient archeological and paleontological materials were covered over in place. Susan Keates, a member of my team who is a graduate student at Oxford University, is analyzing the collections of artifacts from Xiaochangliang. She reports that the ratio of waste flakes to artifacts that were used as tools is consistent with the ratios we have come to expect at sites where tools were actually made.

The sediments that accumulated over a long period of time in the Nihewan Basin were washed down from uplifting mountains, such as the nearby Taihang (Great Navigating) Mountains, to the south, and the Xiong'er (Bear's Ears), a smaller string of mountains within the northern limits of the basin itself. The original topography of the ancient landscape is not known, but it may have been a deep basin containing streams and lakes, including one central, large lake. Now exposed by the erosive action of the Sanggan River, the stream and lake sediments cover at least 800 square miles and range from 900 to 3,600 feet in depth.

The fossil mammals discovered in the Nihewan include ancient species of rhinoceroses, straight-tusked elephants, deer, and horses. The horses include both *Equus,* the modern, one-toed genus, and the primitive three-toed *Hipparion.* The presence of *Hipparion* a million years ago represents a late survival of a form that had already disappeared from Europe and most of Asia. (Coincidentally, at the much later but not distant site of Xujiayao, Wei Qi and his colleagues have uncovered a massive horse butchery site, where the lower jaws of the animals were



broken in order to retrieve an ancient delicacy, horse tongue.)

A surprise at the Nihewan was a giant hyrax. Today, the hyrax survives only in Africa and Turkey and, although a relative of the elephant, is usually house-cat size (it is the "coney" mentioned in the Bible). When first found decades ago, the fossils were thought to belong to claw-toed relatives of the horse and rhinoceros known as chalicotheres. Because they were nearly the size of lions, their true identity long remained unrecognized.

Susan Keates has speculated that the ancient shorelines of the Nihewan represented an ultimate "happy hunting ground" for human ancestors. Bears, saber-toothed cats, hyenas, wild dogs, and foxes were present and no doubt competed for prey—their telltale gnaw marks and damage are found on fossil bones throughout China. But at the site of Xiaochangliang, where stone tools are found along with the animal bones, the few carnivore marks that exist appear to have been left by small creatures, such as foxes or weasels, and the only large carnivore bones belong to hyenas. Apparently, early humans were in command of at least this portion of the ancient lakeshore.

One of the puzzles about Xiaochangliang is that fish fossils are extremely rare in the sediments containing artifacts. My guess is that the ancient lake, at least in this vicinity, was too saline or alkaline for aquatic vertebrates, while the streams that fed it, although fresh, may have been too ephemeral and shallow to support fish. A study of the remains of microscopic crustaceans by Manuel Palacios, of the University of Arizona, confirms that the lake was saline. We have also found small freshwater mollusks that probably lived in the streams. The fresh water would have attracted mammals, providing early humans with opportunities to hunt or scavenge meat (humans, incidentally, are among the relatively few mammals that require water on a daily basis). This kind of habitat—a brackish lake fed by freshwater streams—has been suggested for Olduvai Gorge and Lake Turkana in East Africa.

The Nihewan resembles the East African localities in that it has never witnessed the kind of dramatic climatic fluctuations that caused abrupt extinctions and rapid replacement of animal species in parts of Europe and North America. Warmer and colder periods are reflected in the fossils and geochemistry, but there is no evidence that the region was subject to glaciation. Somewhat cold-adapted forms, such as the woolly rhino, are found there, but not the true glacial-edge-adapted animals such as woolly mammoths, marmots, and reindeer. The Nihewan is also comparable to Olduvai Gorge and Lake Turkana in having been inhabited continuously since human ancestors first appeared in the region.

Scattered throughout at least the northeastern end of the basin (where Xiaochangliang is located) are massive outcrops of bedrock containing fine-grained siliceous cherts and flints, a concentration of raw material easily worked into stone tools that is rare in the nearby loess region. This is of particular interest to me because it bears on the longstanding controversy as to why stone tools in China and other parts of the Far East appear crude and unstandardized compared with those elsewhere in the Old World. Originally, both archeologists and some human paleontologists suggested that the Far East was a cultural backwater, isolated from the "mainstream" of human evolution. More recently, I and others who work in this part of the world have suggested that in the densely forested regions of Asia, stone tools were not as important to their makers as artifacts made from bamboo and other perishable materials, and that the manufacture of early Asian artifacts did not emphasize the production of standardized stone tool kits (*see* "Bamboo and Human Evolution," *Natural History*, October 1989).

Xiaochangliang borders the open habitats of the Siberian steppes, falling a little beyond the range of the monsoon forests of East and Southeast Asia. I therefore expected the stone tool kits found there to reflect this transitional geographic position. I learned something more surprising, however: many of the artifacts from the Nihewan Basin are quite standardized and exhibit forms and attention to detail that are highly unusual at such an early age in this part of the world. Indeed, many resemble artifacts from the much later site of Zhoukoudian.

The majority of tools are garden-variety scrapers, common throughout the Old World for a million years or more, but the tool kits include notched scrapers, burins, triangular points, and artifacts that look like hand axes but are much smaller (about two inches long, compared with the more typical six to twelve inches). Disk-shaped borers, blades, and points have also turned up, all of which show signs of wear or of retouching during their use. These types of implements normally suggest a much more recent technology—no more than a few hundred thousand years old—prompting other archeologists to question the dates. The observations just do not fit the sequences and classifications of early Stone Age technology known in Europe and Africa. But past experience has taught me that standard interpretations applicable elsewhere do not work well in the Far East.

Most paleoanthropologists agree that the first populations of *H. erectus* to spread into Asia colonized the tropical and subtropical forests of Southeast Asia and China. There, I believe, they learned to make many of their tools from bamboo and other woodland plant resources. As some of their descendants migrated northward to more open areas, however, they needed to rely more on stone. My working hypothesis is that, as a transitional zone that offered easily worked stone, the Nihewan fostered experimentation, leading to the development of sophisticated tools at a comparatively early time. A little farther to the north, in Siberia, the tool kits are later in date and more commonly resemble those of Europe. This may indicate that Siberia was culturally connected to Europe or that *H. erectus* returned to making more conventional types of tools as the species spread north from China into the more open tundra and grassland.

Not just the "hand axes" but all the Nihewan tools are relatively small, ranging from five-eighths to two and a quarter inches long. In China small tools and large tools have rarely turned up together. For example, small tools are found at Zhou-



At the lakeshore site of Xiaochangliang, early Asians butcher three-toed and one-toed horses. Chert outcrops yield abundant raw material for stone tools, used to process animal carcasses and manufacture wooden implements, such as spears.
Michael Rothman

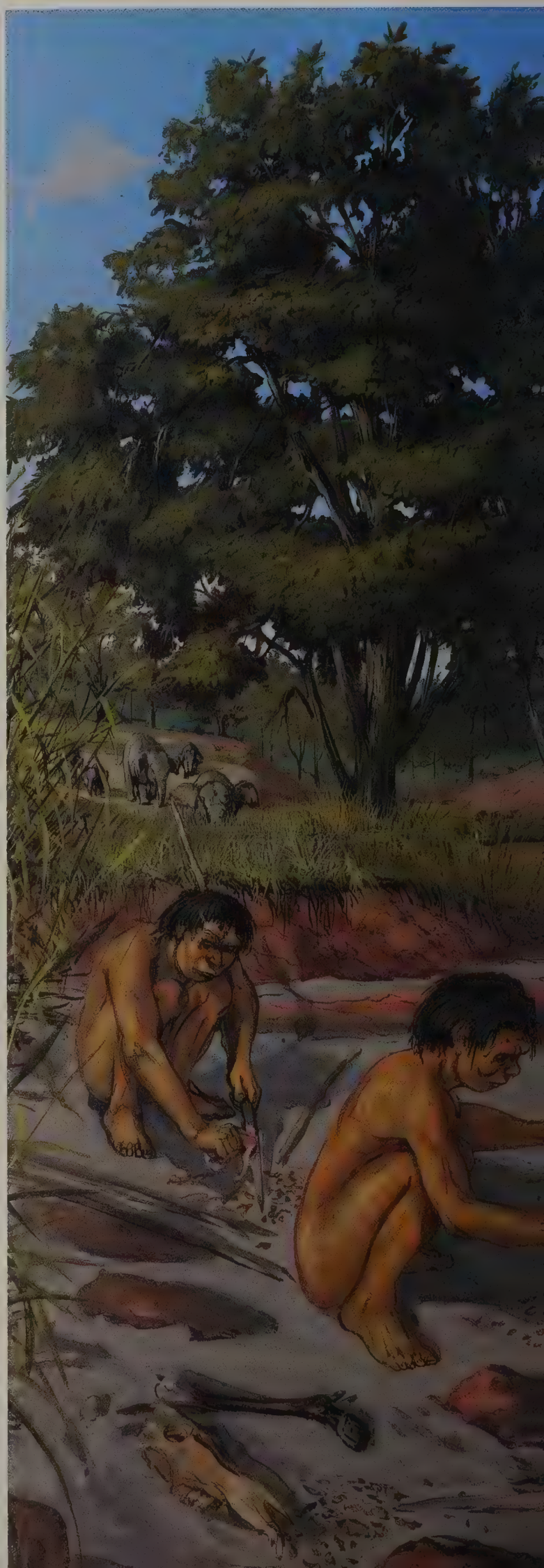
koudian, Xujiayao, and Xiaonanhai, while large ones typify Gongwangling, Kehe, and Xihoudu. This dichotomy has provoked debate among archeologists. Jia Lanpo, the dean of Chinese prehistory, and his colleagues argue that the two kinds of tool kits represent two different cultures or traditions. In their view, Nihewan would fall in the "small tool tradition."

I suspect that both tool kits were created by the same people as they traversed a varied landscape, depending on what they needed to extract local resources. This type of interpretation is commonplace in the West but almost heresy in China. The study of microscopic evidence of wear may resolve the debate by showing that large and small tools were used for different purposes, such as meat processing, hunting, or woodworking.

As we continue to uncover and reconstruct the Nihewan environment and the activities of its ancient human inhabitants, the relevance of this material to an even more hotly debated topic has already become apparent. Some scholars have concluded that all modern humans and modern races originated from a relatively recent group of Africans, whose descendants spread throughout the Old World and replaced all the indigenous early humans. This scenario is based on studies of mitochondrial DNA that suggest all living human populations share a common female ancestor who lived in Africa no more than 200,000 years ago. The "Eve hypothesis," as it is popularly known, has been elaborated with speculation that these modern people prevailed in part because they possessed a superior technology.

But the known archeological sites in the Nihewan (and elsewhere in the Far East) show no indication that a superior, more standardized stone-tool technology was rapidly introduced. Instead, toolmaking appears to continue largely unchanged well after the descendants of Eve are supposed to have arrived. Furthermore, the artifacts from Xiaochangliang now show that relatively sophisticated technologies arose in localized parts of the Far East as early as, or earlier than, in Europe. Apart from this, my own studies of the fossils of *H. erectus* in Asia convince me that a number of their anatomical traits were passed on to modern populations of the Far East, an observation first made by paleoanthropologist Franz Weidenreich a half century ago.

The Nihewan Basin probably stopped filling with stream and lake sediments at least 100,000 years ago, when the nearby mountains ceased their continual uplift. The once-enormous lake system was replaced by the modern Sanggan River and its tributaries, which carved through the ancient sediments to create the steep gullies and canyons visible today. Although most of the ancient animals familiar to the human occupants eventually disappeared, the humans remained and developed new survival strategies. Delicate "microlithic" blades found very close to Xiaochangliang are the work of later hunters and gatherers who were physically modern humans. They may even have been the distant ancestors of the farmers that today aid Wei Qi on his relentless search for artifacts, animal fossils, and, if all goes well, the long-sought remains of *H. erectus*. □







The Dawn of Adornment

Forty thousand years ago, humans began to fashion ornaments and images. Why?

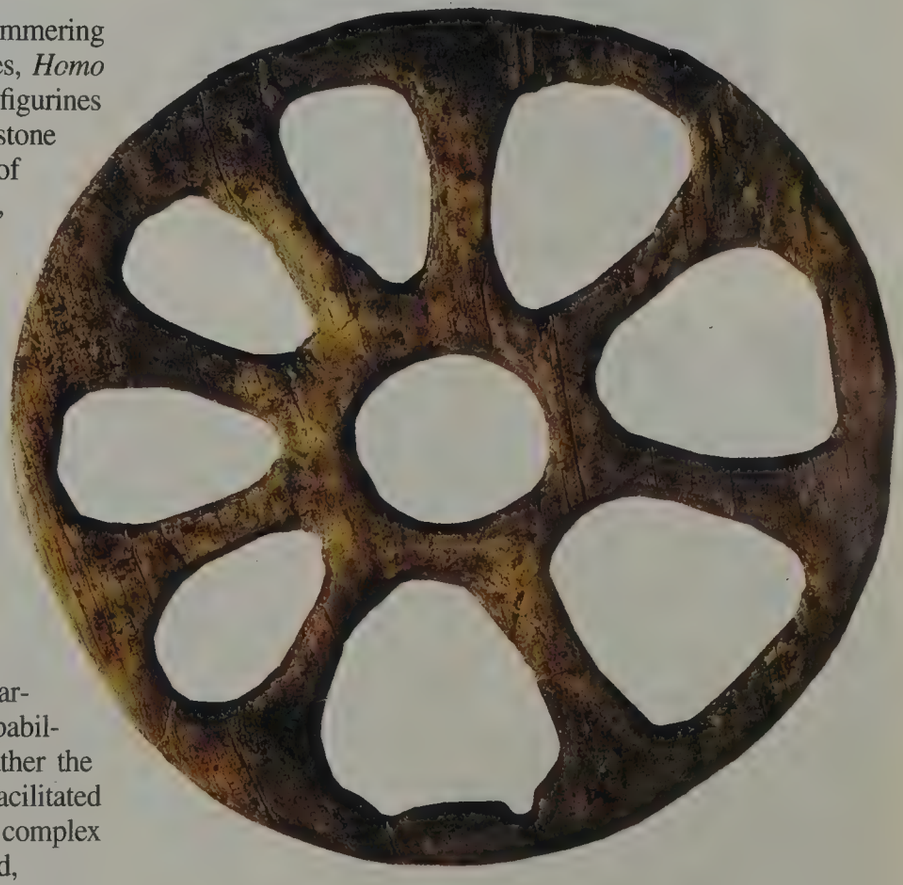
by Randall White

Some 2.5 million years after our ancestors began hammering out stone tools, early members of our own subspecies, *Homo sapiens sapiens,* started sculpting animal and human figurines from ivory, engraving and painting images on limestone blocks, and carefully crafting personal adornments of ivory, shell, soapstone, and animal teeth. In Europe, these creations, as well as innovative stone tools and weapons, first appeared about 40,000 years ago, well before the famous 17,500-year-old cave paintings at Lascaux. They were the work of the Cro-Magnons, successors to the Neanderthals (*H. sapiens neanderthalensis*). Although they had successfully occupied Europe and western Asia from about 200,000 years ago, the Neanderthals had shown only glimmerings of symbolic representation, doing little more than collecting fossils, minerals, and other objects that held some attraction for them. They vanished from Europe several thousand years after the Cro-Magnons appeared.

The rapid emergence of personal ornamentation in particular may have marked, not a difference in mental capabilities between Cro-Magnons and Neanderthals, but rather the emergence of new forms of social organization that facilitated and demanded the communication and recording of complex ideas. As anthropologist Andrew Strathern has observed,

> What people wear, and what they do to and with their bodies in general, forms an important part of the flow of information—establishing, modifying, and commenting on major social categories, such as age, sex and status, which are also defined in speech and in actions. Whatever the precise origins of clothing, then, they can be sought only within the general context of the development of social communication and of society itself.

A clue that social factors played a key role in this cultural watershed is that significant innovations in technology seem to have been developed not so much to improve hunting or gathering efficiency as to achieve aesthetic goals. For example, during the Aurignacian cultural period (about 40,000 to 28,000 years ago), the Cro-Magnons devised various techniques for working ivory, including the preparation and use of metallic abrasives (notably powdered hematite) for polishing. They used ivory in the creation of beads, pendants, and figurines, but almost never for manufacturing utilitarian weapons and tools.



At the Russian site of Sungir, a carved ivory disk, above, was unearthed from the grave of two children who died 28,000 years ago. The fragments of a 26,000-year-old ivory figure, opposite, were discovered in Moravia. Constructed of several parts, it was a burial offering. Both artifacts are shown approximately one and one-third times actual size.

Randall White



Anibal Rodriguez



Randall White

Bead making followed a regular sequence during the Aurignacian cultural period in France. A thinned blank of ivory, viewed from the side, left, was perforated by gouging, above, center, and then ground and polished into a bead, finished examples above, right. Ivory beads and pierced fox teeth from the Sungir burials, below, fall into an interlocking pattern when strung.

Randall White





In addition to ivory, the Cro-Magnons made representational objects from mammal bones and teeth, antlers, fossil and contemporary species of marine and freshwater shells, fossil coral, limestone, schist, talc-schist, steatite, jet, lignite, hematite, and pyrite. They did not choose these raw materials at random. Some came from sources hundreds of miles away, possibly obtained by trade. Only a dozen or so of the thousands of shell species available on the Atlantic and Mediterranean shores were transformed into personal ornaments. Only the teeth of certain animals were chosen. In some cases, the Cro-Magnons crafted ivory and soapstone facsimiles of these same marine shells and animal teeth.

Techniques for producing Aurignacian ivory and stone beads varied from one European region to the next. In France, the most common beads, represented by more than 1,000 specimens dated to between 33,000 and 32,000 years ago, were created in several steps. The Cro-Magnons first fashioned pencillike rods of ivory or soapstone, inscribed them circumferentially at intervals of one-half to three-quarters of an inch, and then snapped off cylindrical blanks. These they thinned and perforated by gouging from each side, rather than by drilling (the technique of choice elsewhere). The roughed-out beads were then ground and polished into their final form, using hematite as an abrasive.

At the 36,000-year-old site of Kostenki 17 in the Don Valley of Russia, archeologists have discovered ornaments made from fossil coral and from belemnites, the fossilized, cigar-shaped shells of a kind of extinct squid. Beads made from belemnites are a translucent gold or brown and are easily mistaken for amber. The bead maker began with the naturally cylindrical belemnites, cut them into segments, split each segment to make semicylin-

Randall White





A 26,000-year-old sculpture from Moravia, probably the head of a lion, is reproduced here about two and one-half times its actual size. It was modeled from moistened loess (a fine-grained soil) and then fired—at least ten millennia before people began making ceramic vessels.
Randall White

drical blanks, perforated them by drilling from each side, and polished them into final form. Similar techniques were used to make ivory beads at contemporaneous sites in central and western Europe.

The inhabitants of the Russian site of Sungir, an open-air camp, wore elaborate personal ornaments of ivory and schist and carved geometric and animal forms out of ivory. At 28,000 years, the site is one of the oldest in which archeologists have discovered ornaments on human skeletons. The remains include the skeleton of a sixty-year-old man, buried in one trench, and the skeletons of two children (one aged seven to nine, the other about thirteen) buried head to head in another. Based primarily on differences in the grave goods, Russian physical anthropologists believe the younger child was a girl and the older one was a boy.

These three burials were decorated with thousands of painstakingly prepared ivory beads arranged in dozens of strands, perhaps originally basted to clothing. Although the three who died apparently were members of the same social group, the burials differed in the details of body decoration and grave offerings. For example, the man's forearms and biceps bore a total of twenty-five polished mammoth-ivory bracelets, some showing traces of black paint. Around his neck, he wore a small, flat schist pendant, painted red with a small black dot on one side.

As was common elsewhere, the beads were mass produced in a methodical, step-by-step fashion. They were scored across each face so that when strung they would fall into an interlocking, criss-cross pattern. Careful analysis shows that the scoring was done on each blank bead before the hole was drilled, indicating that the creator had the desired aesthetic effect in mind at even the earliest stages of production. Experiments reveal that each bead took more than an hour to make.

The adult male burial contained about 3,000 beads, while each child's burial contained 5,000. Thus the man's beadwork required more than 3,000 hours of labor, while that of each child took more than 5,000 hours. The other objects placed on and alongside the children's corpses also represented a greater investment of labor. The extra attention lavished on the children may simply show that those who buried them felt a very deep loss. But it could mean the children had inherited a high social rank. If so, hierarchical societies arose—contrary to what some have assumed—well before economic systems based on agricultural production.

In creating representational images, the Cro-Magnons applied many of the techniques employed in the production of personal ornaments. They shaped three-dimensional ivory and steatite sculptures by gouging, grinding, and polishing. Such sculptures were often perforated for suspension. An experimental reconstruction of an ivory horse from the south German cave site of Vogelherd took archeologist Joachim Hahn nearly forty hours. The Cro-Magnons also marked limestone slabs. Frequently they first smoothed the surface by abrasion. Then they used diverse techniques—engraving, pecking, chiseling, gouging, and occasionally painting—to make desired lines.

The several dozen Aurignacian engraved blocks that have been discovered are difficult to interpret. Their arrays of punctuations, cup marks, incisions, and notches form few recognizable images. The dominant engraved sign—an oval or triangle partly bisected by a line—has been commonly identified as a representation of the vulva. An alternative interpretation is that such signs, as well as other arrangements of cuplike marks, represent hoof prints. Such symbolism could have arisen from a very natural association between animals and their tracks.

Perhaps the most unexpected object that has survived from Aurignacian times is a flute from the site of Isturitz in southwestern France. Made of bird bone, which is naturally hollow, it had at least three finger holes. This flute indicates that in addition to other forms of expression, the Aurignacians also had music. At least a dozen more such flutes are known from the succeeding cultural period, the Gravettian (roughly 28,000 to 22,000 years ago).

The Gravettian period also witnessed the emergence of the first fired ceramics, which appeared in central and eastern Europe about 26,000 years ago. Many thousands of fragments of animal and human figurines, as well as kilns for their production, have been recovered from sites in Moravia, in what is now the Czech Republic, and Russia. The figurines were shaped from

Institut für Urgeschichte, Tubinge

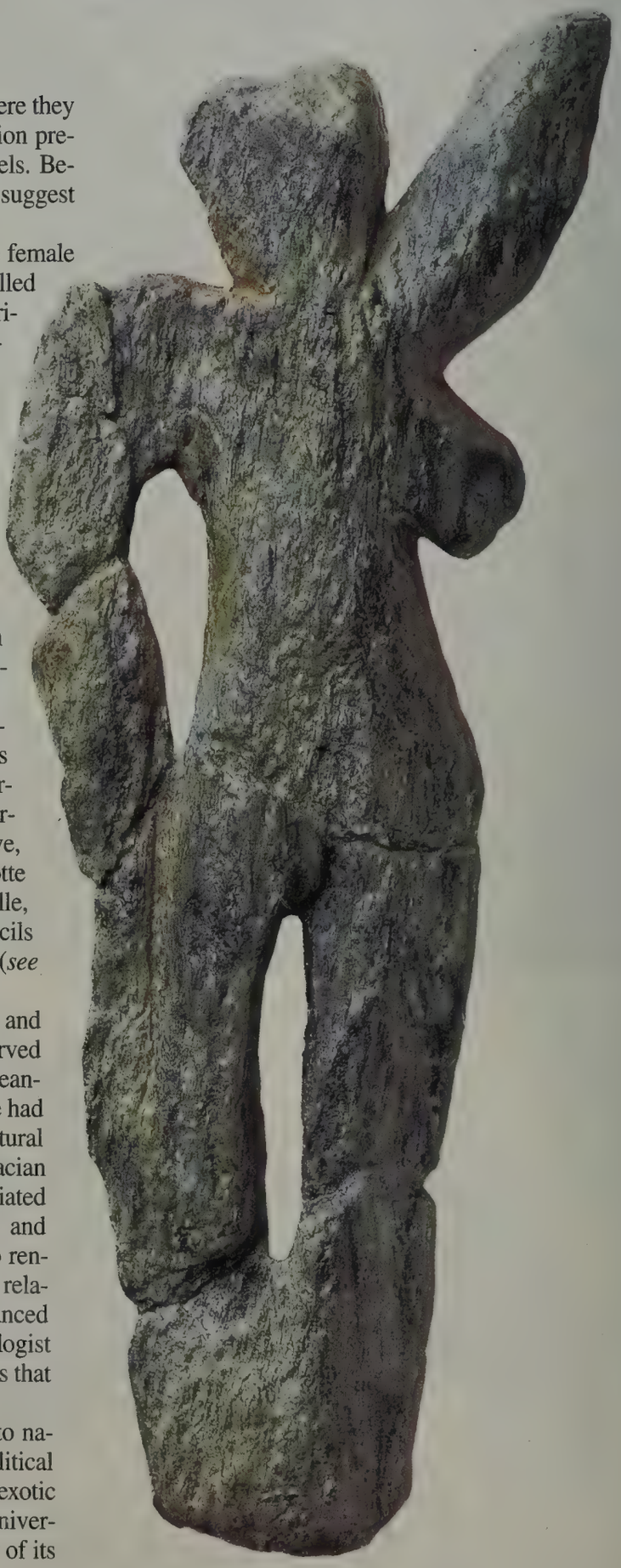


Carved from ivory 33,000 years ago, a horse from the German site of Vogelherd, above, may have been a pendant. Another animal pendant, left, was discovered at Sungir. Made of polished ivory, it was colored with red ocher and dotted with drill holes filled with black manganese. Both pendants are about two inches long.

Randall White



A female figure of serpentinite, below, strikes an uncommon pose for a 30,000-year-old sculpture. It is from the Austrian site of Galgenberg and stands two and three-quarter inches high. Right: Made of fired loess, this four and one-half inch statuette of a woman, possibly pregnant, is from Moravia.
British Museum (Natural History), London



moistened loess, a fine sediment underlying the campsites where they have been found, and fired at high temperatures. This invention preceded by at least 10,000 years the first known ceramic vessels. Because the figurines are often fragmented, some archeologists suggest that the kilns were purposely designed to explode them.

By far the most famous Gravettian representations are the female statuettes and bas-reliefs popularly (but inappropriately) called Venuses. Some are ceramic, but others are sculpted from a variety of materials—ivory, limestone, steatite, and calcite. Varying regionally in form and manufacturing technique, they are found throughout Europe. At the 26,000-year-old site of Avdeevo, in Russia, Maria Gvozdover and her colleague Gennadi Grigoriev have excavated more than a dozen such figurines, nearly as many as have been found at all of the other sites of this age in western Europe combined. Most were sculpted from the tusks of woolly mammoths and depict women in the late stages of pregnancy, frequently in birthing postures. Many were buried in pits, sometimes more than one to a pit. In some cases, different fragments of a broken statuette were buried in pits dug several yards apart. This careful placement must have reflected some ritual concern.

Gravettian sites have also yielded numerous animal engravings, often done in a rather stiff, flat style, with the lower limbs left unfinished. Finally, the Gravettian is famous for its numerous hand stencils, found at habitation sites beneath rock overhangs and in shallow to medium-depth caves. One French cave, Gargas, has more than 150 hands stenciled on its walls. In Grotte Cosquer, the underwater cave recently discovered near Marseille, the charcoal-based paint used to spray the numerous hand stencils has now been radiocarbon dated to about 27,000 years ago (*see* "Neptune's Ice Age Gallery," *Natural History,* April 1993).

This great commitment of labor, technological innovation, and creativity implies that ornamentation and representation served practical, adaptive functions for early Cro-Magnon people. Neanderthals and their contemporaries outside of Europe may have had the mental capacity to use lines and materials to represent natural objects—some apparently did so when exposed to Aurignacian cultures—but on their own they do not seem to have appreciated the advantages of such exercises. Cro-Magnons used two- and three-dimensional forms of representation systematically—to render concepts tangible, to communicate, and to explore social relations and technological possibilities. This powerfully enhanced their evolutionary fitness. As University of Miami archeologist Heidi Knecht has argued, the ability to simulate visually things that do not yet exist is essential to any degree of innovation.

Around the world today, images and icons—from tattoos to national flags—are frequently brandished to assert social and political authority. Personal ornaments, constructed of rare, sacred, or exotic materials or requiring great labor, knowledge, or skill, serve universally to distinguish people and groups. Modern culture in any of its diverse forms is unimaginable without the kind of material symbols that humans first devised 40,000 years ago. □



Captain Cook's Naturalist

by Ghillean T. Prance

Sir Joseph Banks (1743–1820) was one of the most remarkable naturalists of the eighteenth century, so it is appropriate to issue this most readable biography in the year in which we celebrate the 250th anniversary of his birth.

In August 1768, the twenty-five-year-old Banks set out for Tahiti on the *Endeavour,* to observe the transit of Venus. Commissioned by the Royal Society (founded in 1660 to promote "Physico-Mathematical Experimentall Learning") the *Endeavour,* under the command of Capt. James Cook, left England, crossed the Atlantic via Madeira to Rio de Janeiro, rounded Cape Horn and crossed the Pacific to Tahiti, New Zealand, Australia, and New Guinea, and finally returned to England by way of the Cape of Good Hope and Saint Helena.

Joining the crew as the expedition's naturalist, Banks, who came from a wealthy family, could afford to fund his own team of workers: Swedish naturalist Carl Solander, three artists, and four general collectors. Although they missed the transit of Venus because of bad weather and although two of the artists, Alexander Buchan and Sydney Parkinson, died on the trip, the three-year expedition was successful not only in its explorations but also in bringing back to England extensive botanical, zoological, and ethnographical collections. This epic voyage was the making of Banks's career.

Banks's journal, from which O'Brian quotes liberally, provides vivid accounts of the trip. One particularly desperate situation, when the *Endeavour* went aground out of sight of shore, signals the first European contact with the 1,250-mile-long Great Barrier Reef. After the crew threw forty tons of goods overboard

the ship was almost afloat and every thing was ready to get her into deep water but she leakd so fast that with all our pumps we could just keep her free: if (as was probable) she should make more water when hauld off she must sink and we well knew that our boats were not capable of carrying us all

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JOSEPH BANKS: A LIFE, by Patrick O'Brian. *David R. Godine, Boston, $29.95; 328 pp., illus.*

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ashore, so that some, probably the most of us, must be drownd: a better fate maybe than those would have who should get ashore without arms to defend themselves from the Indians or provide themselves with food, on a countrey where we had not the least reason to hope of subsistance.

Miraculously, the ship did not sink and repaired to the Australian coast to be refitted. A measure of the success of Cook's command was confirmed by Banks:

During the whole time of this distress I must say for the credit of our people that I beleive every man exerted his utmost for the preservation of the ship, contrary to what I have universaly heard to be the behavior of sea men who have commonly as soon as a ship is in a desperate situation begun to plunder and refuse all command.

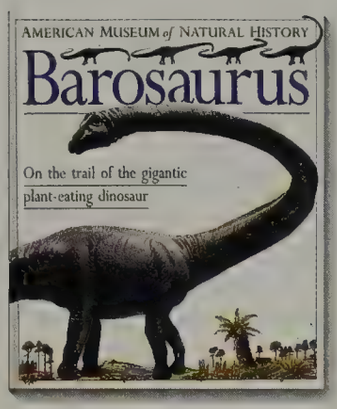
Once on land, Banks left the concerns of the ship to Cook and set to work collecting. He recorded his first sight of a kangaroo:

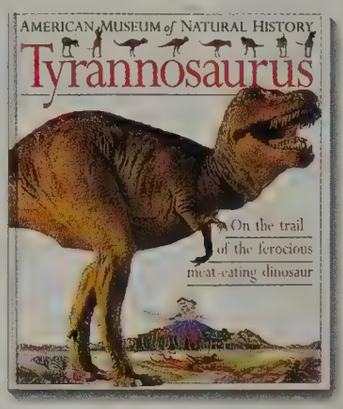
In gathering plants today I myself had the good fortune to see the beast so much talk'd of, tho but imperfectly; he was not only like



An eighteenth-century engraving shows the Endeavour *on the Queensland coast, where she was hauled up on shore after striking a reef.*
Hulton Deutsch Collection, London

On the Trail of the Titans of Prehistory...

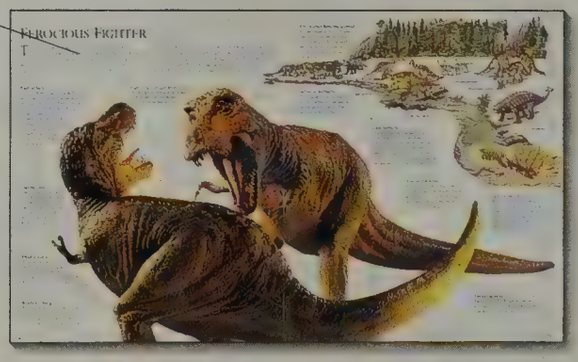




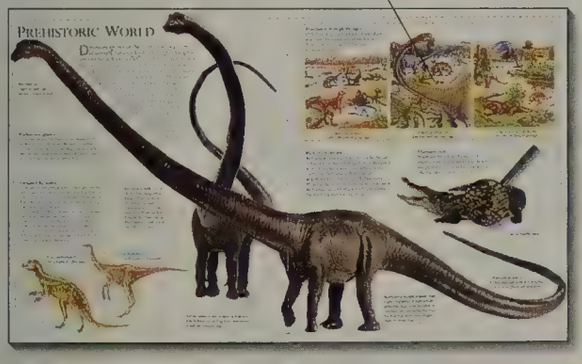
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a grey hound in size and running but had a long tail, as long as any grey hounds; what to liken him to I could not tell, nothing certainly that I have seen at all resembles him.

When I consider my own difficulties collecting in Amazonia, I am amazed to find that, in addition to the birds, fishes, mollusks, and other animals he gathered, Banks and his team brought back some 30,000 plants (3,500 different species) pressed in unbound copies of Milton's *Paradise Lost*. Perhaps the expedition's greatest contribution was Sydney Parkinson's collection of plant drawings, which Banks converted into eighteen-by-twelve-inch plates accompanied by detailed text.

Curiously, Banks never published these portfolios, possibly because he feared criticism or thought too little of his abilities. In responding to an invitation to join the Belles Lettres Society in 1807, Banks offered this disclaimer: "I am scarce able to write my own Language with Correctness, and never presumed to attempt Elegant Composition, Either in Verse or in Prose in that or in any other tongue." As Patrick O'Brian points out, whatever the explanation for his turn of mind, Banks's published writings amount to little more than a few pamphlets. *Banks's Florilegium,* a compendium of 738 plates that Banks bequeathed to the British Museum when he died, was finally published in 1988.

On his return to England, Banks settled into an active life. Appointed botanical adviser to the gardens of King George III in 1772, he resolved with typical enthusiasm to make them the best collection of living plants in Europe. He succeeded, although the Royal Botanic Gardens at Kew was not formed as a public entity until 1840, twenty years after his death.

Using his influence with the king, his later position as president of the Royal Society, and his personal fortune, Banks organized many collecting expeditions for Kew all over the world. At Banks's instigation, the Scot Francis Masson, who first collected hundreds of plants and bulbs in South Africa for the royal garden, was sent to the Canaries, the Azores, Madeira, and the West Indies. Kew still has the cycad *Encephalartos altensteinii,* probably the oldest surviving potted plant in the world—which was brought back from that trip and planted in 1775. It has survived many upheavals, including the recent restoration of the great Palm House.

Another Scot, Archibald Menzies, of the Edinburgh botanic garden, was a naval surgeon with a bent for natural history. Largely through Banks's influence, Menzies joined the crew of Capt. George Vancouver's *Discovery* as its naturalist. He introduced the monkey puzzle tree to Kew by taking some seeds of the tree's edible nut from the banquet table at an official function in Chile.

In addition to sponsoring explorers in Africa, including John Ledyard, James Bruce, and Mungo Park, Banks assigned David Nelson, a Kew gardener, to be naturalist aboard Captain Bligh's unfortunate *Bounty*. In launching the *Bounty* expedition, Banks was not only interested in gathering plant specimens for English gardens and dried specimens for herbaria but also in moving plants to different parts of the British Empire. He equipped the *Bounty,* as O'Brian points out, "into a truly botanical ship, a gardener's floating paradise," with the purpose of transporting the breadfruit and other useful plants from Polynesia to the West Indies. Although the *Bounty*'s mission ended in mutiny and failure, Captain Bligh made a successful second voyage on which he introduced many South Sea plants to Saint Helena, Saint Vincent, and Jamaica. One of these plants, the akee (*Blighia sapida*), or vegetable marrow, has become almost the national food of Jamaica.

Banks is remembered as a botanist and as a patron who sponsored numerous collectors. He was also very much a part of English society. His marriage in 1779 to a socially prominent heiress, Dorothea Hugessen, was apparently a happy one, although they had no children. Banks's genius for friendship went to such an extent that, according to O'Brian, "his amiability outweighed his judgment so that self-seeking people took advantage of him." He delighted in the society of natural philosophers, and his Soho Square house became the chief meeting place for men of science. His diaries and correspondence show that he had many famous friends and correspondents, from Samuel Johnson and Joshua Reynolds to French naturalist Baron Georges Cuvier and Swedish botanist Carl Linnaeus.

One of Banks's later protégés was a young botanist, William Jackson Hooker, whom Banks sent on an expedition to Iceland in 1809, a voyage that ended in disaster when the ship caught fire. Although Hooker and his fellow passengers were rescued, his collections of plants, birds, and minerals, and even his precious journal, were lost. This did not deter Hooker, however, and with notes and memoranda lent to him by Banks, he wrote a book about Iceland from memory. Hooker be-

came the first official director of the Royal Botanic Gardens in 1841, twenty-one years after the death of Banks.

Banks had many other interests besides the Royal Society and the royal gardens. He was a man of order whose farms prospered while those of many other contemporaries lost money. He managed his properties and still found time for fishing, shooting, and archery. At his home near Kew, he grew many of the exotic plants that were brought back for the royal gardens. He even developed a cranberry bog on the island in his pond there.

While Banks was a man of sobriety and composure, he was also capable of boyish enthusiasm. Upon Banks's election to the presidency of the Royal Society, a fellow member, the antiquarian and botanist the Reverend Sir John Cullum, recorded:

The President came in a great hurry, quite out of breath, and sitting down (I was opposite to him) said with good humour, but with rather too little dignity: "I believe never did a President of the Royal Society run so fast before." However, his behavior throughout was very proper.

After forty-two years as the Society's president, the seventy-seven-year-old, gout-ridden Banks submitted his resignation in March 1820. It was not accepted, and Banks died in office eighteen days after being informed of the decision.

O'Brian has created a rich portrait of a man who not only became a renowned naturalist but also fostered the careers of many others. O'Brian ends the book with a letter from Banks to Hooker, leaving us with his "living voice, not quite pleased, to be sure, but not at all rancorous either." Seventy years old at the time and confined to a wheelchair, Banks advised Hooker against a stay-at-home life of ease:

Let me hear from you how you feel inclined to prefer Ease & indulgence to Hardship and activity I was about 23 when I began my Peregrinations you are somewhat older but you may be assured that if I had Listend to a multitude of voices that were Raisd up to dissuade me from my Enterprise I should have been now a Quiet countrey Gentleman ignorant of a multitude of matters I am now acquainted with & probably have attained to no higher rank in Life than that of a countrey Justice of the Peace.

Botanist Ghillean T. Prance, an expert on Amazon flora, is director of Great Britain's Royal Botanic Gardens, Kew. Formerly senior vice-president of the New York Botanical Garden, Prance is the author of eleven books and more than 200 scientific papers.

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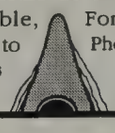


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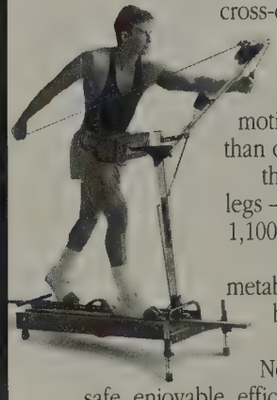
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At the American Museum of Natural History

The Hall of Human Biology and Evolution

The newly opened Hall of Human Biology and Evolution features a replica of a frieze from Lascaux, a mural of early primate evolution by painter Jay Matternes, a hologram of the internal systems of a woman's body, an "electronic newspaper" with updates on the latest discoveries in human biology and evolution, and four life-sized dioramas depicting our prehistoric ancestors in scenes of everyday life.

In conjunction with the Hall's opening, three scholars will explore questions in human prehistory. The lecture series, "New Perspectives in Human Evolution," will be held on Thursday evenings at 7:00 P.M. in the Main Auditorium. The first lecture will be given on May 13 by Eric Delson, research associate in the Museum's Department of Vertebrate Paleontology; the second, on May 20, by Jeffrey T. Laitman, director of gross anatomy in the Department of Cell Biology and Anatomy at Mount Sinai School of Medicine; and the third, on May 27, by Donald C. Johanson, director of the Institute of Human Origins and discoverer of the 3.2-million-year-old hominid "Lucy." Tickets are $30. Call (212) 769-5310 for ticket availability.

National Astronomy Day

Telescope viewings, sundial workshops, and special performances of *Wonderful Sky* and *Robots in Space* will be given to celebrate National Astronomy Day on Saturday, May 1, between 10:00 A.M. and 2:00 P.M. Call (212) 769-5900 for more information.

Observing Gamma Rays

Gamma ray bursts, an important and mysterious astrophysical phenomenon, will be the subject of a talk by Gerald J. Fishman of the NASA Marshall Space Flight Center. This slide-illustrated talk, on Monday, May 17, at 7:30 P.M. in the Sky Theater, is part of the "Frontiers in Astronomy and Astrophysics" series. Tickets are $8 ($6 for members). Call (212) 769-5900 for information.

The Earth in Perspective

The annual "planet-walk" through the solar system will take place on Sunday, May 23, at 1:00 P.M. on the Museum's grounds. Developed in 1969 by astronomer Guy Ottewell, the walk follows a thousand-yard-long model of the universe. Volunteer guide Robert Campanile will lead the tour. A program for the hearing impaired will be held on Saturday, May 22, at 1:00 P.M. For more information, call (212) 769-5566.

Geology for Travelers

For travelers interested in geology, Sidney S. Horenstein, coordinator of the Museum's environmental programs, will explain basic geological concepts and how to classify various types of landscapes. The slide-illustrated talks will be given on Tuesday, May 11, and Tuesday, May 18, at 7:00 P.M. in the Kaufmann Theater. Tickets are $25 for both. For information, call (212) 769-5310.

Antarctica at Naturemax

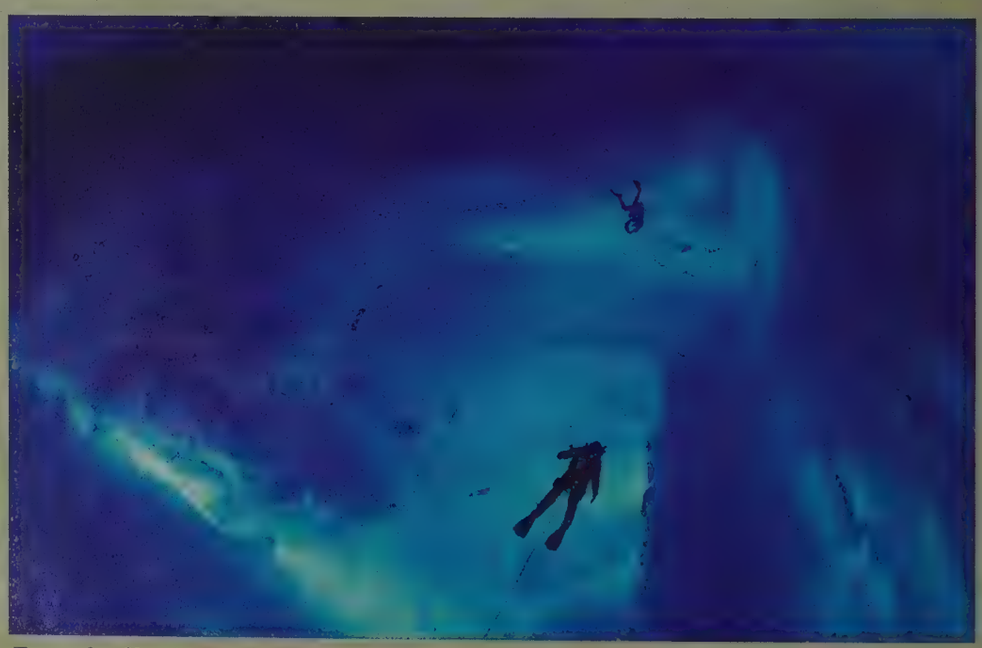
The film *Antarctica,* portraying the highest, driest, coldest, and most mysterious continent on earth, will open at the Naturemax Theater on Saturday, May 1. Daily showtimes are 10:30 A.M., 11:30 A.M., 1:30 P.M., and 3:30 P.M. *Tropical Rainforest,* which depicts the 400-million-year evolution of the rain forests, will continue to be shown at 12:30, 2:30, and 4:30 P.M. daily. *Antarctica* and *Tropical Rainforest* will be presented as a double feature on Friday and Saturday evenings at 6:00 and 7:30 P.M. A dinner/theater package for $21 ($19 for members) includes Museum admission, double feature, and dinner in the Garden Café. For reservations call (212) 769-5350.

Journey to the Far Side of the Sun

The classic science-fiction film series continues with *Journey to the Far Side of the Sun,* a 1969 British film about an astronaut who visits a planet that is an exact duplicate of the earth. Directed by Robert Parrish, it stars Roy Thinnes, Ian Hendry, and Herbert Lom. Brian Sullivan, the Hayden Planetarium's production designer, will introduce the movie with a thirty-minute slide show on Saturday, May 1, at 3:00 P.M. in the Kaufmann Theater. Tickets are $7 ($4 for members). Call (212) 769-5606.

They Married Adventure

Martin and Osa Johnson entertained American audiences of the 1920s and 1930s with films of faraway places, exotic people, and the dramatic spectacle of African wildlife. Pascal James Imperato and Eleanor M. Imperato, authors of *They Married Adventure: The Wandering Lives of Martin and Osa Johnson,* will give a slide-illustrated talk focusing on the Johnsons' association with the Museum and with Carl Akeley, inventor, sculptor, and taxidermist. The lecture



From the film Antarctica, *now at the Naturemax Theater*
Museum of Science and Industry, Chicago

will be presented on Wednesday, May 12, at 7:30 P.M. in the Kaufmann Theater. Tickets are $6 ($3 for members). Call (212) 769-5606 for ticket availability.

Northwest Coast Totem Poles

The skills necessary to carve a forty-two-foot totem pole, as well as the traditional ceremonies and family involvement in totem-pole ritual, will be discussed by Vickie Jensen, author of *Where the People Gather: Carving a Totem Pole.* Two lectures will be given, the first on Wednesday, May 26, and the second on Thursday, May 27, at 7:00 P.M. in the Kaufmann Theater. Tickets for both are $25. Call (212) 769-5310.

Maroon Film Festival

Maroons, or runaway slaves who formed their own communities, will be the subject of programs on Saturday and Sunday, May 15 and 16, from 1:00 to 4:00 P.M. in the Kaufmann Theater. The Department of Education will present films and discussions of America's maroon societies as part of its series on colonial encounters with indigenous populations. Call (212) 769-5315 for a complete schedule of events.

Tyrannosaurus Rex: Hunter or Scavenger?

Probably the largest scavenger and carnivore to have lived on land, *T. rex* will be the subject of a talk by paleontologist John Horner. His new findings in Montana include estimates of *T. rex*'s speed (as fast as that of an Olympic sprinter), proof of its warm-bloodedness, evidence that its forelimbs were shorter but more powerful than previously thought, and indications of its stereo vision and keen senses of smell and hearing. The program will be held on Monday, May 24, at 7:00 P.M. in the Kaufmann Theater. Tickets are $10 ($5 for members). Call (212) 769-5606.

These events take place at the American Museum of Natural History, located on Central Park West at 79th Street in New York City. The Kaufmann Theater is located in the Charles A. Dana Education Wing. The Museum has a pay-what-you-wish admission policy. For more information about the Museum, call (212) 769-5100.

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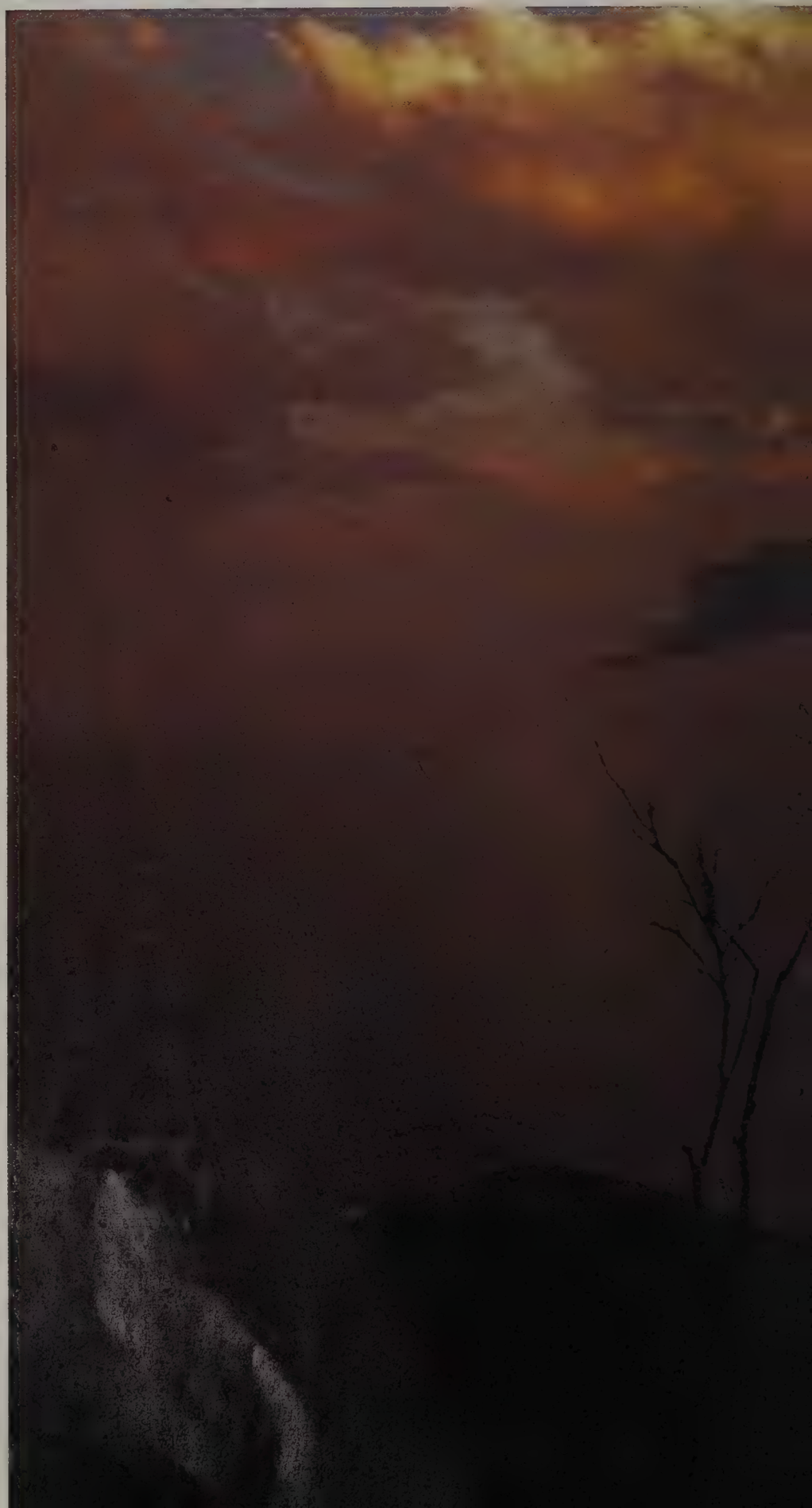
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Forillon National Park, Québec

by Robert H. Mohlenbrock



At the extreme northeastern tip of Québec, the Gulf of Saint Lawrence pounds relentlessly against the cliff wall that edges Canada's Forillon National Park. My wife and I arrived at Cap Bon Ami, a rocky projection into the gulf, during a strong autumn storm that had deluged the area since daybreak. We stood huddled under our ponchos as the waves smashed into the rocks with a continuous roar, sending sprays of seawater scores of feet into the air. Eventually the rain began to subside, the sky brightened, and a vibrant rainbow appeared, seemingly within our reach.

The limestone exposed at Cap Bon Ami and the adjacent 800-foot cliffs was uplifted 350 million years ago, according to park naturalist Maxime St. Amour, who has spent more than twenty years studying, photographing, and writing about Forillon. Through the millennia, the mountains have eroded several thousand feet down to their present configuration. Lichens cling tenaciously to the cliff faces, a habitat too severe for most plants, owing to the gales, the short growing season, and the shade cast during parts of the day by the cliff. Only a few wildflowers survive in the rocky crevices, while stunted spruces line the edge of the cliff-tops.

Among the plants growing along the cliffs are some of the same species found in the arctic tundra or at high elevations in the Rocky Mountains and the Sierras.

Although a boreal forest covers the interior of Forillon National Park, only the hardiest of plants can survive on the rugged coastline.

Bill Brooks; Masterfile





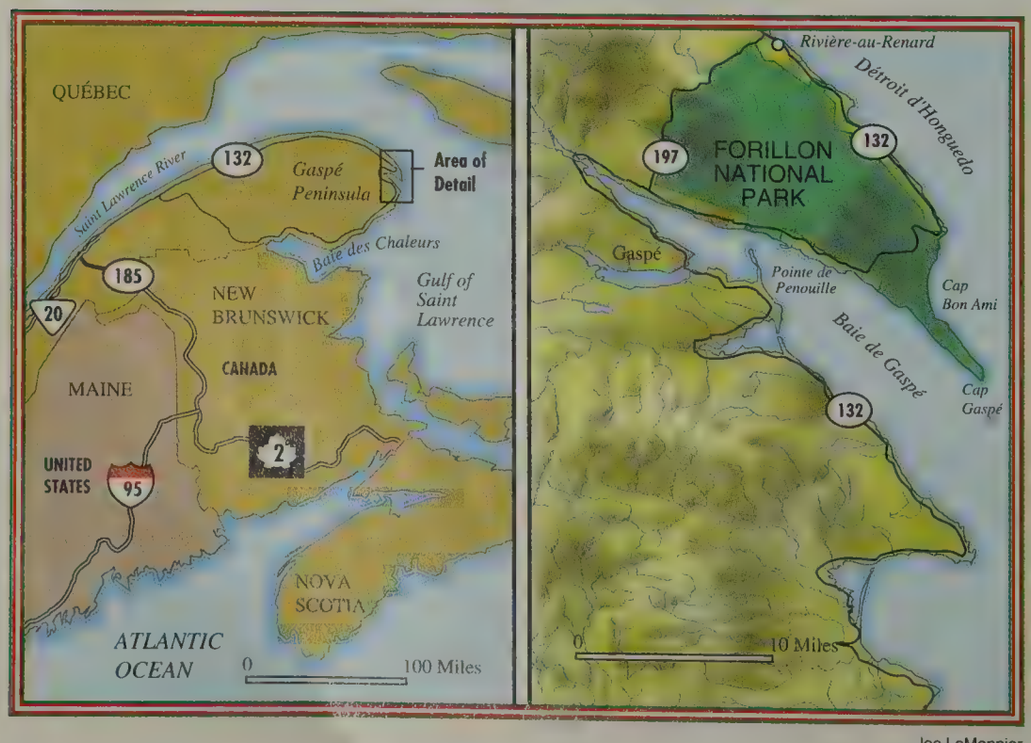
Uplifted 350 million years ago, the limestone layers at Cap Gaspé have been worn down by the gale winds and pounding waves of the Gulf of Saint Lawrence.
Art Gingert; Wildlands Photography

St. Amour explains how these now-isolated populations of plants arrived and survived at Forillon: During the Ice Age, when great glaciers covered the northern latitudes, tundra species migrated southward. As the last of these glaciers melted away, beginning more than 10,000 years ago, the land beneath the retreating ice was exposed. After the ice had receded far northward, a bare strip a few miles wide extended from the Gaspé all the way to the Rocky Mountains. Those plants that could survive the rigorous conditions colonized this zone. These included not only tundra plants but also Rocky Mountain species, which extended their range eastward along the narrow corridor all the way to the Gaspé. As the climate continued to warm, however, a boreal forest covered most of the area, and the arctic-alpine species remained in only the harshest environments, where forest plants were unable to grow.

St. Amour lists nearly thirty species of plants, called relicts, that were left behind in Forillon as remnants of the Ice Age. Introduced from the western North American mountains are the yellow dryas, with graceful, nodding yellow flowers above a cluster of leaves, and the spear-leaved arnica, with yellow, daisylike flowers. The alpine bistort, which produces narrow, inch-long spikes of white flowers, is unusual among the relicts because it lives in very moist habitats. Arctic tundra plants include the white dryas, a tufted saxifrage with white flowers, and the scirpioid sedge—all three are dwarf species, rarely more than eight inches tall.

The arctic-alpine plants of the exposed cliffs are only a fragment of the diverse vegetation found in Forillon. A boreal forest, containing a mixture of deciduous trees and evergreen, cone-bearing trees, covers about 95 percent of the park. The predominant species are white fir, white birch, and yellow birch. But in a few very small areas, where the local conditions are milder, the forest takes on a decidedly New England look, with tiny stands of sugar maple, American elm, red oak, and white ash rising above bloodroot and other wildflowers.

One of the most unexpected plant communities occupies a 50-acre area close to the south shore of Forillon, near Pointe de Penouille, a sand spit that juts into the Baie de Gaspé. It is a forest of mature but rather dwarfed black spruces growing above a carpet of crunchy lichens. This type of vegetation, known as taiga, normally constitutes a transition zone between tundra and boreal forest. Forillon's taiga forest lies nearly 500 miles south of the main taiga region of North America and is unusual among such outliers because it grows near sea level rather than at a higher altitude. It may have survived there because the porous sand is unsuitable for competing species, providing poor anchorage for boreal forest trees, which are also discouraged by the soil's high acidity. Except for the black spruces and lichens, vegetation in the taiga is sparse, with the most common plants being false heather, black crowberry, low-bush blueberry, stunted pussytoes, and a dwarf goldenrod. The black spruces have evolved an adaptation to the sandy terrain, forming runners, or stolons, from ground-level branches. These runners form a network from which new shoots periodically rise and take root.



Joe LeMonnier

Robert H. Mohlenbrock is professor emeritus of plant biology at Southern Illinois University, Carbondale. This month he takes a Canadian break from his usual beat, the 156 U.S. national forests.

Forillon National Park

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May Day, Pagan Style

by Gail S. Cleere

In Chet Raymo's wonderful book *365 Starry Nights,* he describes in his unique way just what happens when the earth starts to warm up in springtime: "In its journey around the Sun the Earth leans into its curve like a sailor bracing against the wind.... [The Sun's] rays hit the Earth's surface more directly here in the northern hemisphere, and the Earth responds.... Every second the Sun converts 657 million tons of hydrogen into 653 million tons of helium by a process called nuclear fusion. The missing 4 million tons of mass are converted into energy and hurled into space as heat and light.... The Earth intercepts only about 4 pounds worth of that vanished matter, but to the Earth that 4 pounds worth of energy is the difference between day and night, winter and summer, life and death."

In May, the earth seems to pause in this yearly journey, giving us time to shake our winter-weary heads, feel the earth warming up, and spend more time looking at the nighttime sky. And so we celebrate.

I am always delightfully surprised to learn that one or another of our most time-honored festivals or traditions has its basis in a knowledge of the stars and their changing patterns with the passage of time. Astronomer Ed Krupp says that "our awareness of time and our need to organize it are fundamental underpinnings of consciousness.... Our ancestors first started noting the passage of time [with] observations of celestial cycles." In ancient times this knowledge "had power—religious power, economic power, political power. [It] sustained society and for that reason was expressed in sacred ritual.... Long before we became farmers or built civilizations, our brains must have focused on the rhythmic changes in the sky and measured the behavior of the world in terms of them. Survival depended on it."

And so it is with May Day, an intermediate calendar date that for some ancient cultures further divided the year into smaller, more manageable intervals. Early Bronze Age stone circles in northern Europe—Long Meg and her Daughters in Cumbria, Castle Rigg in the Lake District—seem to bear this out. These have stones aligned to the sunrise on these intermediate dates, just as the better known circles (such as Stonehenge) are aligned to the solstices and equinoxes. But perhaps the greatest evidence of the importance of these intermediate dates is found in the traditional holidays still observed in England and, in some cases, the United States. Candlemas (Groundhog Day) in February, May Day in May, Lammas Day in August, and Martinmas in November.

May Day was called Beltane by the ancient Celts. On this day, the sun rises midway between the place where it rises along the horizon on the spring equinox (due east), and its northernmost rising point on June 21, the summer solstice. The significance of May Day was not lost on the Celts. Beltane was a full-blooded pagan ritual day, when the protection of the gods during the newly begun growing season was invoked in a variety of ways. The earliest traditions were terrifically sinister. To appease three deities, three separate lethal punishments were given to a person choosing the Beltane cake, a burned piece of grain pancake, in a sacred ritual lottery. In 1984 near Manchester, England, a peat cutter discovered one such sacrificial victim: the well-preserved body of a man, who proved to have been murdered about A.D. 50. The victim had been axed so hard that the tops of his molars had been sheared off. A noose had then been twisted around his neck, crushing his windpipe. Finally, his jugular was lanced, and he was dumped in a bog. A burned piece of grain bread was found in his stomach. The British tabloids named him Pete Moss.

Over time, Beltane gradually was cleansed of its more gruesome aspects (thanks for the most part to the coming of Christianity), so much so that by the nineteenth century in England, Maypoles, garlands, and tea parties were the general order of the day. Today, even these tradi tions are dying out, but one thing has no changed: May's starry skies herald the be ginning of the growing season, and stars o no, we still depend on this.

As if Mother Nature wants to trick us however, the early evenings of May ar not as impressive as the winter and sum mer evenings. Except for the Big Dippe the constellations in the sky are faint, an only later at night do our faithful friends o summer return—Scorpius, Sagittarius and the beautiful Summer Triangle. As th month progresses, they get higher an higher, earlier and earlier. Patience eventu ally pays off.

The Planets in May

Mercury is barely visible at the end o the month, very low on the northwestern horizon just after sunset. The planet is nea the 2d-magnitude star El Nath in Taurus.

Venus, called Phosphorus by the Greeks, is our morning "star" this month On the 7th, it reaches its greatest brilliancy of the month, –4.5 magnitude, which is nearly eight times brighter than Jupiter and almost sixteen times brighter than Sirius, the brightest star in the nighttime sky. On the mornings of the 17th and 18th, watch the waning crescent moon pass through Pisces just above Venus.

Mars has moved from Gemini into the faint constellation Cancer the Crab and is now fast approaching the constellation Leo and its bright star Regulus. The red planet is high in the west–southwest as evening skies darken, and sets about five hours later. Mars is now only one-eleventh as bright as when it was closest to the earth in early January. If you have binoculars, be sure to train them on Mars on the evenings of the 12th and 13th when it will be passing only about half a degree above the Praesepe, or Beehive, star cluster (M44). On the 26th, look for Mars 7° above the first-quarter moon.

Jupiter is in the constellation Virgo, not far from the bright star Spica, and can

e seen high up along the southern merid-
n (the imaginary line that bisects the
ome of the sky from south to north) after
nset. On the night of May 2, the waxing
oon pays a call just south of Jupiter.

Saturn is low in the southeast in the
edawn skies of May, passing through the
m constellation Aquarius. Aquarius is in
area of the sky filled with faint constel-
tions associated with water—Cetus the
Whale, Delphinius the Dolphin, and Pis-
s the Fish. The ancient world associated
is part of the sky with water seemingly
ecause the sun entered it when spring
ins began. In ancient Babylon, the aster-
m represented a man pouring water from
urn. Nearly a century ago, popular as-
onomer Garrett Serviss wrote that the an-
ent Egyptians imagined that Aquarius
used the yearly flooding of the Nile "as
e sank his huge urn in the river to fill it."
waning moon visits Saturn in Aquarius
the morning of the 14th.

Uranus and **Neptune** remain close to-
ether in eastern Sagittarius not far from
aturn in the early-morning sky. Look for
em with binoculars nearing the meridian
efore sunrise. On the night of the 10th,
e waning moon passes just above.

Pluto reaches opposition on May 14,
eaning that this tiny planet (there was a
ove several years ago to unseat it as a
lanet!) rises opposite the sun as the sun
ts. In midevening, Pluto can be found
with a large telescope) high overhead
earing the meridian.

The **Moon** is full on May 5 at 11:34
M., EDT; reaches last quarter on May 13
8:20 A.M., EDT; is new on May 21 at
0:06 A.M., EDT; and reaches first quarter
2:21 P.M., EDT, on the 28th.

On the 21st, May's new moon will par-
ally eclipse the sun. For North America,
is is an early-morning event that will be
isible north and west of a great sweeping
ne from central Baja California, through
estern Texas, southern Illinois, Lake
rie, Lake Ontario, the Gulf of Saint
awrence, and Labrador. Inexperienced observers are cautioned to observe only projected images of the eclipse (for example, through a pinhole onto a sheet of paper). Looking directly at the sun, even through many types of filters, can cause serious and permanent damage to your eyes.

More of Halley's Comet

On the night of the 4th, the earth passes through the stream of frozen particles left behind when Halley's comet passed around the sun. These are the Eta Aquarid meteors, named not for the comet but for the place in the sky from which they seem to emanate (a faint star in the faint constellation Aquarius). Just after midnight, in the early hours of the 5th, your location on the earth is spinning directly into the cometary debris so that you see more meteors streaking through the sky. Unfortunately, the moon is very near full during this year's shower and hence will likely obliterate all but the very brightest meteors. Under more favorable circumstances, an observer might hope to see perhaps ten to twenty meteors per hour.

And where is Halley's comet today? At a sheepish 25th magnitude (nearly 40 million times fainter than the faintest naked-eye star), it is barreling outward at about 1.5 miles per second toward the orbital path of Uranus (which it crosses next year). From our perspective, it is hiding in the constellation Hydra, not far from the planets Mars and Jupiter.

Amid dire predictions that the earth would be poisoned by Halley's comet, enterprising salesmen eighty-three years ago did a brisk business in elixirs and comet-pills on the 21st, when the earth may have passed through the outer fringes of the tail of this great comet.

Gail S. Cleere writes on popular astronomy and is a founding member of the International Dark Sky Association, an organization dedicated to preserving the skies for astronomy.

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Sun Food

Once upon a time, the pancake, the crêpe, and the blin were all signs of spring

by Raymond Sokolov

In the recent movie *Groundhog Day,* Bill Murray plays a Pittsburgh TV weatherman who has to go to Punxsutawney, Pennsylvania, on February 2, to see if the local pet *Marmota monax* will see his shadow or not. The weatherman has done this every year, but this time a hitherto tedious assignment turns into a nightmare. A blizzard forces him to spend the night in Punxsutawney, and the next morning it is Groundhog Day again. And the next morning, and on and on, again and again, until love puts things right and the calendar resumes its normal advance.

Amusing as it is, this film will probably not do well outside the United States, since few people elsewhere are aware of Groundhog Day. On the other hand, Europeans do celebrate a holiday on the same date, the traditional Christian feast called Candlemas. Although it officially commemorates the presentation of the infant Jesus in the temple, as well as the purification of Mary after childbirth, Candlemas is, in name and in practice, a festival of light. It would seem that this is a survival from pagan days. As with Groundhog Day, light is the key to the observance, and the point of both celebrations must be, in my view, to pledge faith in the coming end of winter. Both the candle and the sun th tempts the groundhog out of his hole a early signs of spring.



Blini with salmon roe and sour cream
Vladimir Morozov; Envision

Why do I think this? Because on Ca dlemas in France (the French call the hol day Chandeleur), it is *de rigueur* to e crêpes. For children, making these thi pancakes has a special folklore that di guises the underlying cosmological signi icance of the crêpe. The successful crêp maker holds a coin (traditionally gold) i one hand and the skillet in the other. Whe the crêpe is done on one side, the chil flips the pancake in the air and catches it i the skillet after it turns over. Failing is ba luck. Napoleon, by legend, amused hirr self in the kitchen by making crêpes ju before his departure for Russia in 181 He flipped four crêpes successfully, bu missed the fifth. The day that Mosco burned, he is supposed to have said t Marshal Ney: "It's the fifth crêpe."

The real meaning of crêpes, and of par cakes in general, is far more profoun Crêpes are round, and they are fried i golden butter, symbolizing the orb of th sun and its golden rays (as does the gol coin French children hold in their hand).

Better known examples of the sam pancake/light/sun/spring symbolic cluste occur on Shrove Tuesday, or Mardi Gras when pancakes are traditional fare in Eng land and Germany. The German *Pfann kuchen,* sometimes called *Ballen,* ar spherical and, therefore, even more he liomorphic.

Perhaps the most elaborate of these pre Lenten pancake celebrations still occur i some places in Russia (*see* "The Death o Winter," *Natural History,* January 1993) For a whole week before Ash Wednesday Russians indulge in a gorging semifas called *maslennitsa* (Anne Volokh in *Th*

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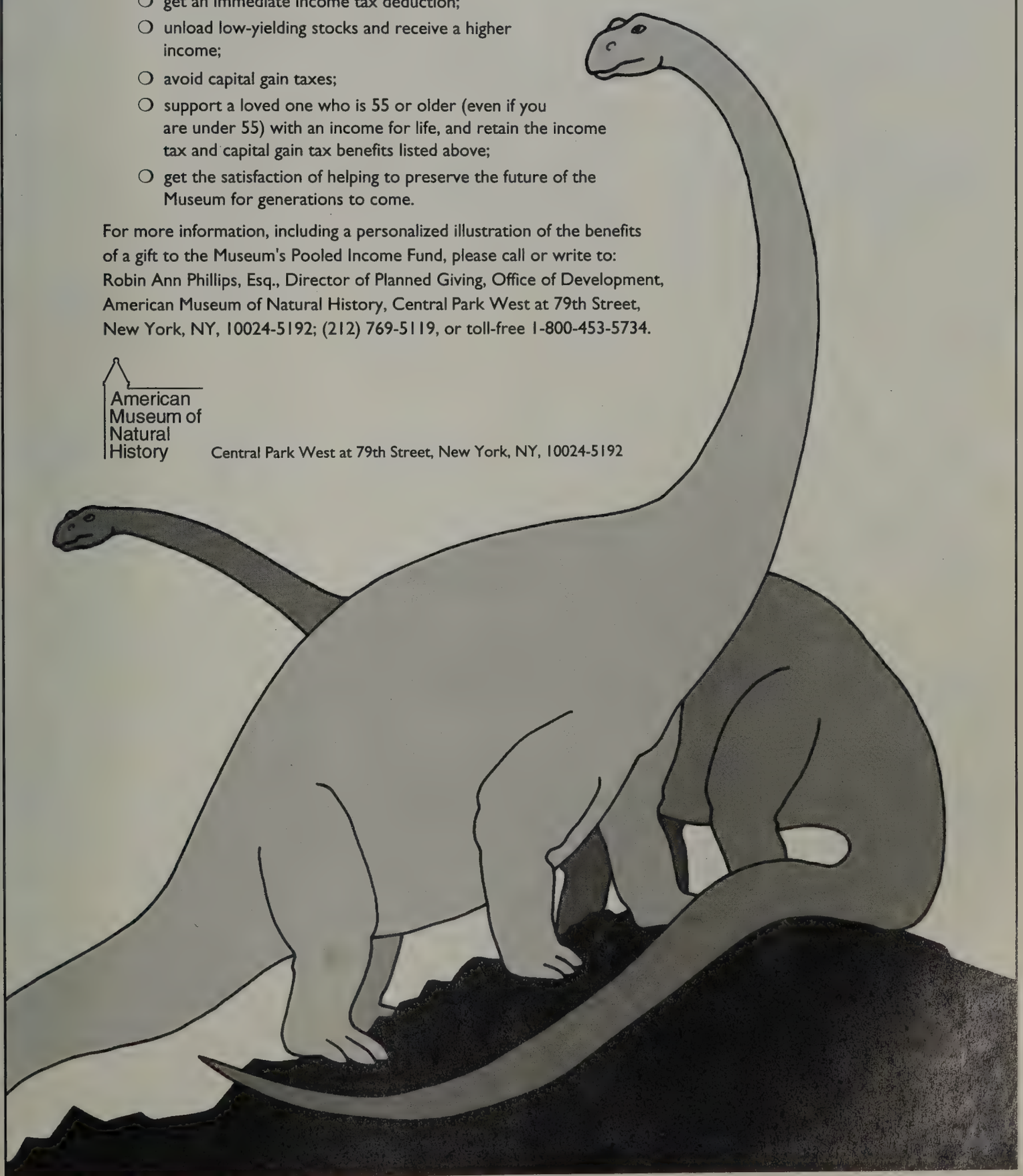
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Art of Russian Cuisine, 1983, translates it as "butterweek"). Everyone eats mountains of the medium-thin pancakes called blini doused in melted butter.

Blini (singular blin) predate the arrival of Christianity in Russia. Indeed, the word itself derived from an earlier form, meaning milled. And every authority seems to agree that the pancakes, whether made from buckwheat or wheat or a mixture of the two, were associated with a pagan sun festival long before any Russian had heard of Easter.

Volokh quotes the turn-of-the-century Russian writer Aleksandr Kuprin's classic description of *maslennitsa*:

> Butterweek dates back to pagan times. Ten days before it actually begins, all of Moscow eats rolls baked in the shape of larks, with little wings, sharp beaks, and eyes made of raisins: the lark heralds the coming of spring, the return of blue skies. Then suddenly, with the first day of Butterweek, everyone switches to *blini,* which represent the Sun God. The *blin* is as round and as golden as the all-warming sun. The piping-hot *blin* is smothered with melted butter. The *blin* is the symbol of fine days, abundant crops, fulfilled marriages, and healthy children.

Blini are eaten with caviar and melted butter, or sprinkled with scallions or smoked fish or sautéed onion. The original blini were made with buckwheat, but an all-buckwheat pancake is not a delicate thing. So a compromise was struck in the modern period. Wheat was added to the buckwheat or used as a substitute altogether. There is also significant variation in the way Russian cooks add or do not add yeast or baking soda to their blini batters. The primordial buckwheat blin was a sourdough pancake, lightened and aerated by natural yeast fermentation. Later, prepared yeast was substituted.

Obviously, these different practices produce widely differing results. I am in no position to pontificate about blini, but I do think that the wide range of recipes, from heavy, sour, yeasty buckwheat pancakes to light, unleavened, thin, all-wheat-flour *blinchiki* in the Russian tradition, conveniently raises fundamental questions about the basic nature of all pancakes.

For north European peoples, pancakes served much the same purpose. They were, as Elizabeth David has written, "a means of using meals and flours such as barley, buckwheat, oatmeal, which were not suitable for bread proper." These primitive pancakes were leavened with yeast and tended to be cooked on griddles or bake stones in houses without ovens. The humble grains people used were not chosen for their taste appeal or their interesting texture, as we would choose them today, but because they would grow in climates inhospitable to wheat. Pancakes, then, were the northerner's home-style sourdough bread in the days before modern transportation made wheat almost universally available.

The convenience of pancakes makes them a popular choice still for breakfast. Nowadays, baking powder substitutes for yeast in most homes. And pancake mixes eliminate even the need to combine the flour and baking powder. Most crucially, wheat flour has infiltrated the pancake world and displaced the hardier grains for which the pancake was first invented.

In fact, almost everything about a modern pancake is different from the traditional sourdough buckwheat varieties. But no one, not even a medieval Saxon arriving in my kitchen via a time machine, would have any trouble identifying a pancake-mix pancake fried in a skillet as a pancake. Obviously, we are dealing with a special category of quick-bread cookery here, but how should this category be defined? One's first impulse is to say that a pancake is nothing more than a piece of dough fried in a pan. But this definition cannot be right. It would include doughnuts, but it would exclude griddle cakes

All right, let's say that deep frying is ou and any lightly greased metal cooking sur face is in. But doesn't that mean that a tor tilla is a pancake? And intuitively w know it doesn't belong here. The problen is with the dough. A tortilla is patted out o a dry, stiff dough. Pancakes are made from batter that's pourable, but they are no fried or poached in a deep liquid bath, like doughnuts or dumplings or spaetzle.

So a pancake starts out as a loose pourable dough (batter) that is cooked on a greased, flat surface. The batter flows nat urally into a flat circle. The cooked pan cake is flexible and can be rolled up into a cylinder that can be stuffed with flavorings and solid food (a subgenre that the French call *pannequets* and which we contribute to by wrapping flapjacks around sausages for pigs-in-a-blanket).

This definition allows for a surprisingly large number of preparations from all around the world. There are Mexican crêpes filled with the corn fungus called *cuitlacoche,* which are New World cousins of Breton buckwheat crêpes and the froufrou crêpes suzette. There are the paper-thin, blue-corn flour griddle cakes rolled into brittle scrolls, called *piki,* by traditional Hopi women, the crisp rice-flour *banh xeo* of Vietnam and the *lumpia*

Crêpes

1 scant cup all purpose flour
3 eggs
1 cup milk
2 tablespoons butter
2 teaspoons rum
½ teaspoon salt

1. Stir the flour gradually into the eggs.
2. Bring the milk to the boil. As soon as it begins to foam, remove from heat and add butter. After the butter has melted and been stirred into the milk, pour the mixture little by little into the flour-egg mixture. Stir with a wooden spoon until you have a smooth batter. Stir in the remaining ingredients. Do not hold this batter more than 15 minutes.
3. Heat an ungreased but well-seasoned 8- or 9-inch cast-iron skillet (or a nonstick frying pan) over medium heat. The right heat is difficult to judge until you try a crêpe or two. Typically, a beginner will lose the first one. Overheating will cause the batter to stick. If this happens, remove the skillet from the heat briefly, lower heat slightly, and try again: Pour ⅓ cup of batter into the pan and then turn the pan back and forth to distribute the batter in a thin film across the whole surface of the pan. The crêpe will cook very quickly. As soon as its surface begins to bubble, either flip it in the air so that it comes down on its other side in the pan or work a small knife or a fingernail under one edge and turn it over by hand. It takes a matter of seconds to brown the second side. Then slip the finished crêpe onto a plate.
4. Continue as above until the batter is all used up. As you finish each crêpe, add it to the pile.
5. Keep them warm until ready to serve. The classic garnish is a simple sprinkling of confectioner's sugar, but you can also use apricot or other preserves, chopped walnuts, or chocolate sauce. If you spread the preserves on the crêpes, add chopped nuts, and roll them up, this is what Hungarians call *palaczinta*. Cover with chocolate sauce or sour cream, warm in oven, and serve.

For crêpes suzette, smear the crêpes with butter, fold in fours, sprinkle with confectioner's sugar, and serve flambé with curaçao.

Yield: 12 crêpes

ins of the Philippines, as well as the ge, dark *dosas* of South India.

Our definition is not perfect. It includes *ki*, because they start as a poured batter, t virtually identical, paper-thin skins ade from real doughs too hard to pour ve to be excluded—strudel, phyllo, and eir first cousins, Moroccan *warka* and hinese spring roll skins. The last two are a special sub-subgenre of pastry made tapping a piece of dough against hot etal so that a film adheres to the metal nd turns into a superthin sheet.

No definition is perfect, but I still think is better to classify these "pancakes" according to cooking method rather than by e way they look when they're completely prepared. In the end, however, ven our neat, functionally defined pancake genre turns out to be a two-headed east. All along, I've been lumping together two obviously different kinds of ancakes—the thick, doughy true pancake nd the much thinner crêpe.

They both fit the basic definition of pancake, but they are also fundamentally different, as a comparison of basic recipes ill show. Harold McGee did such a comarison in his scientific analysis of the tchen, *On Food and Cooking* (Scribner, 984). He quantified common sense by etermining that the main difference beween regular pancakes and crêpes was the lative dilution of the flour in their batrs. Given equal amounts of flour, the tio of water for pancakes and crêpes was 5:23. In other words, crêpes were 1.53 mes more dilute than pancakes. This is hy crêpe batter spreads so easily across e bottom of a skillet. It also explains, ys McGee, why crêpes don't have bakg soda added to them and pancakes do. he thicker pancake can hold the air bubles, but during cooking, the thin crêpe atter loses any air that a chemical raising gent might add to it at the batter stage.

Once you have a stack of crêpes, however, the world is your oyster, so to speak. Whole restaurant menus have been concocted with crêpes, sweet or savory, mixed with God-knows-what. It was not a ecipe for the sublime. There are, of ourse, traditional crêpe recipes of fabuous complexity, in particular some Hunarian crêpe tortes. But the charm of these elicate pancakes is their simplicity and elicacy, their connection with pagan ays—springtime sun on your plate.

aymond Sokolov is a writer whose speial interests are the history and preparaon of food.

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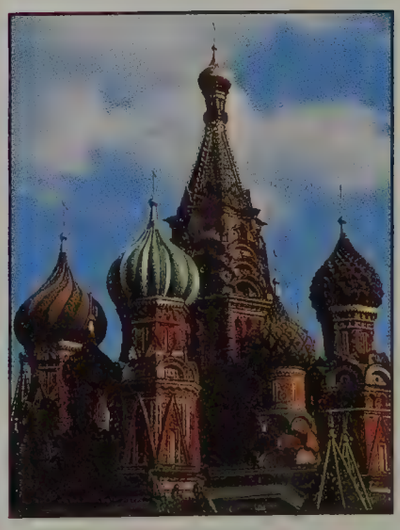


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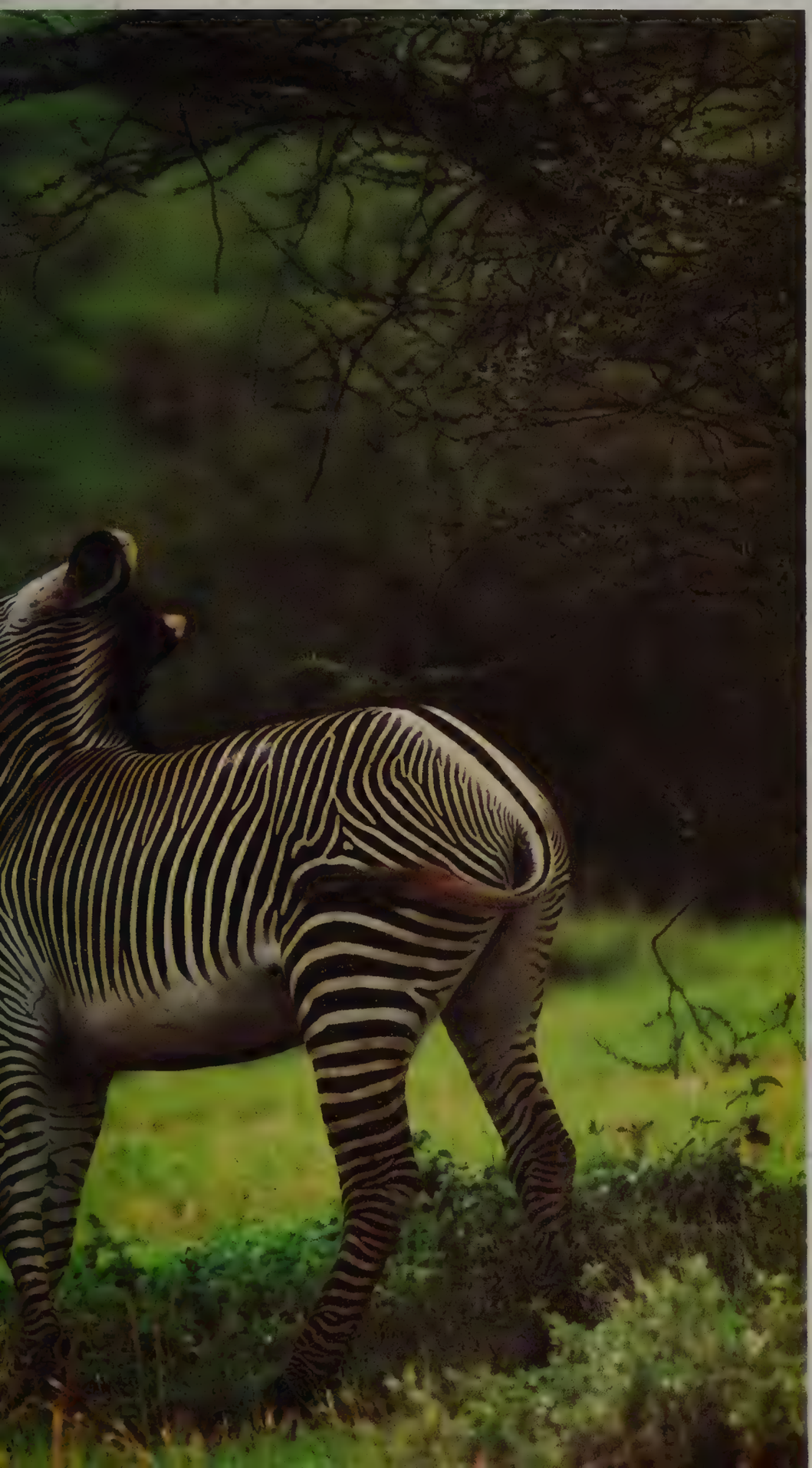


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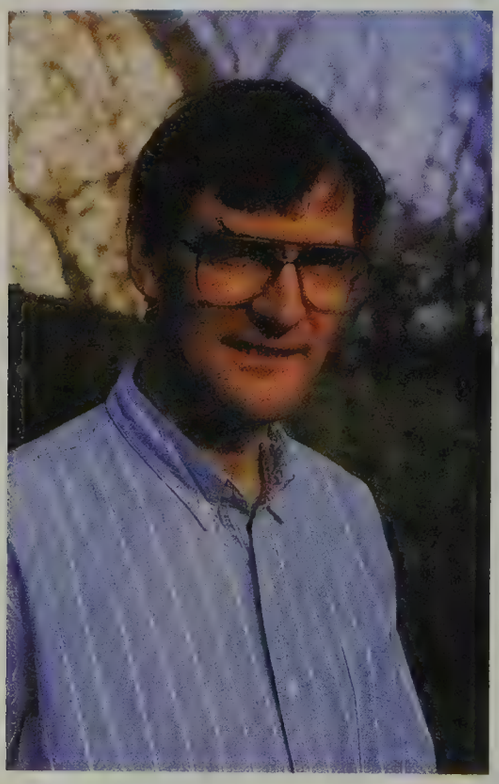
Lucky Stripes



In November, in the green, rain-soaked savanna in Kenya's Buffalo Springs National Reserve, a male Grevy's zebra rears and kicks his front legs in the air—all to impress a potential mate. The courtship ritual of these zebras is more violent than that of other zebras and horses. In this case, the stallion pursued the mare in circles, catching her long enough to bite her neck and repeat his rearing and kicking display. When he attempted to mount her, she kicked up her heels and moved off. The affair, which was accompanied by the stallion's frequent, loud braying, continued for half an hour before the pair finally mated.

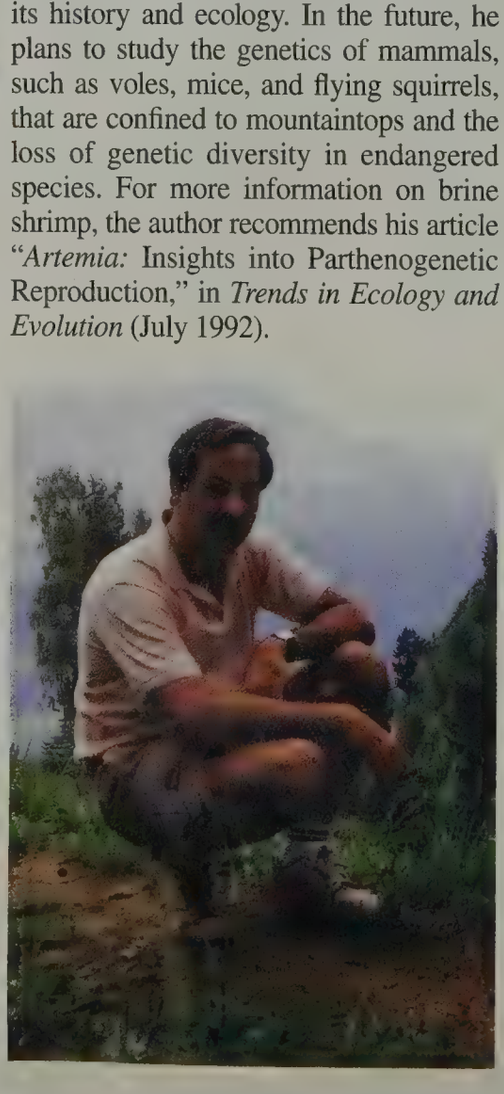
The Grevy's zebra is the largest of the wild equids (more than five feet in height at the shoulders), and its characteristics are considered by some to be primitive, perhaps representing an ancestral form from which horses and mountain and plains zebras evolved. Numbering only several thousand individuals in northern Kenya and southern Somalia, the species has been listed as endangered. Better suited than other zebras to arid conditions, Grevy's zebras generally do not migrate long distances during the dry season. When the grasses have all been eaten, the zebras survive on browse. Stallions dig and defend water holes, abandoning their ranges only in severe droughts. They maintain large territories and guard them for years. During mating season, they have exclusive access to receptive females that wander through their domains.—*R. A.*

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by Stan Osolinski
Dembinsky Photo Associates



Ten years ago, **Michael Hansell** (page 40) was essentially an entomologist, but while writing a book about animal architecture, he expanded his horizons considerably. In the course of forays into the literature on bird nests, he was struck by both the frequency with which silk was mentioned and the relative lack of studies on its actual importance and function. As he set about filling in some of the gaps, he discovered that the richest collections of bird nests are to be found in the basements of natural history museums. Consequently, in addition to conducting fieldwork with graduate students in Scotland, he has visited museums in London, Paris, Edinburgh, and Rouen. The United States is next, he says. In the future, he hopes to examine in more detail the functional architecture of the nest of the riveting long-tailed tit. Readers interested in learning more about the general topic of animals as builders can turn to the classic by Karl von Frisch, *Animal Architecture* (New York: Van Nostrand Reinhold Company, 1983) and Hansell's *Animal Architecture and Building Behavior* (London: Longman Group Limited, 1984).

Photographed in the Swiss Alps, **Robert A. Browne** (page 34) became interested in brine shrimp and their genetics while conducting his postdoctoral research at North Carolina State University, and has studied them for the last fifteen years. Now an associate professor of biology at Wake Forest University in North Carolina, he is also interested in the ecology and evolution of other asexual species. Although he has occasionally felt a little guilty about doing much of his fieldwork on brine shrimp in southern France (and is about to head off to the Greek island of Milos), his research on these tiny invertebrates has also taken him to many arid areas of the world that aren't as pleasant. His first love, however, is the mountains. In 1975, he hiked the Appalachian Trail in 110 days and then wrote a book on its history and ecology. In the future, he plans to study the genetics of mammals, such as voles, mice, and flying squirrels, that are confined to mountaintops and the loss of genetic diversity in endangered species. For more information on brine shrimp, the author recommends his article "*Artemia:* Insights into Parthenogenetic Reproduction," in *Trends in Ecology and Evolution* (July 1992).





Elisabeth S. Vrba (page 47) was born in Germany and raised in Namibia on a karakul sheep farm. She attended the University of Cape Town, graduating in 1964 with a B.S. in zoology and mathematical statistics. Soon after, she started working at Pretoria's Transvaal Museum, cleaning and restoring fossils. Eventually, Vrba became head of the museum's Department of Paleoanthropology, succeeding the legendary Robert Broom, and directed excavations of robust australopithecine fossils at the Kromdraal cave site. Later, she became deputy director of the museum and earned her doctorate in paleontology from the University of Cape Town in 1974. Now a professor of geology and geophysics at Yale University, as well as an adjunct professor of biology there, Vrba's interests include evolutionary theory, brain growth rates in chimps and humans, and the evolution and ecology of African fossil antelopes. For further reading about climate and early hominids in Africa, she recommends her chapter, "Late Pliocene Climatic Events and Hominid Evolution," in *The Evolutionary History of the Robust Australopithecines,* edited by Frederick E. Grine (Hawthorne: Aldine de Gruyter, 1989) and "The Evolution of Man in Africa: Was it a Consequence of Cainozoic Cooling?" by C. K. Brain (Pretoria: Alex L. du Toit Memorial Lectures No. 17, The Geological Society of South Africa, 1981).

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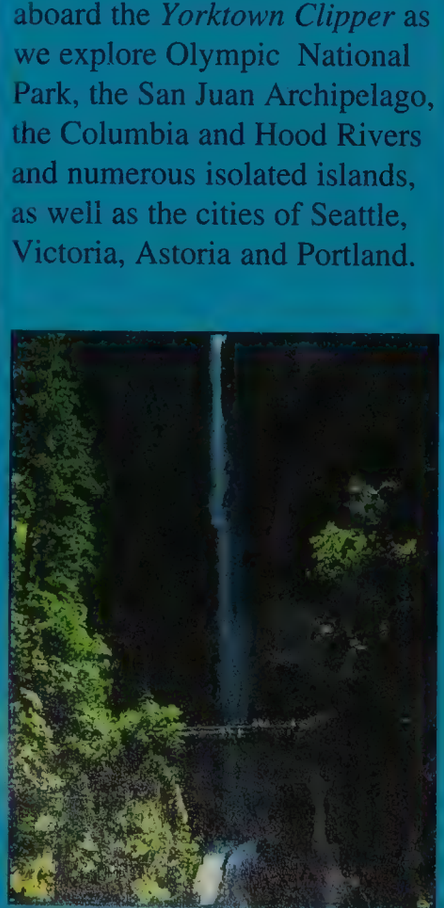
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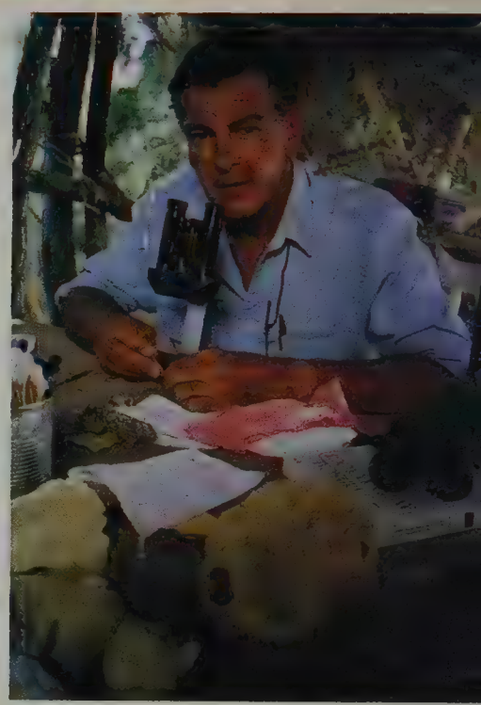
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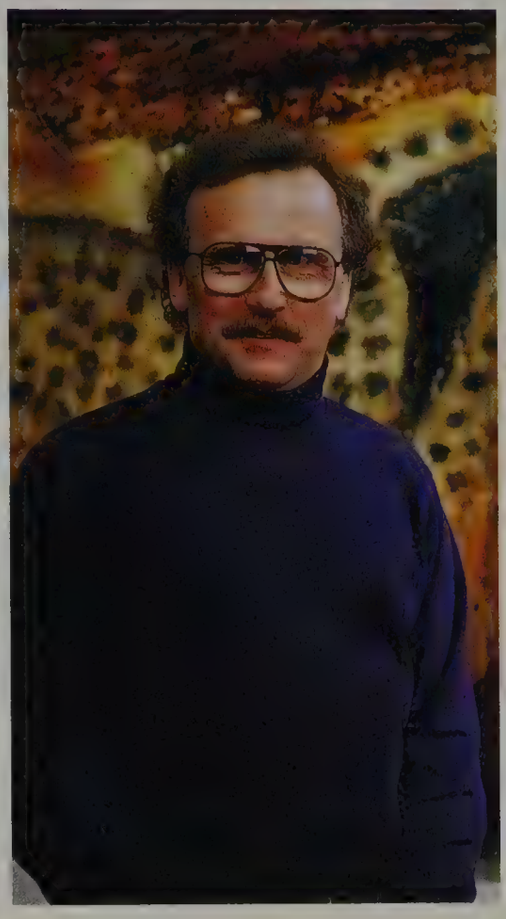
In 1974, after having just completed his doctorate, paleoanthropologist **Donald C. Johanson** (page 52) attained worldwide fame for the discovery of "Lucy," a fossil skeleton from the Afar region of Ethiopia. The species to which Lucy belongs, *Australopithecus afarensis,* remains the earliest known type of upright-walking human ancestor. Founder and president of the Institute of Human Origins in Berkeley, California, Johanson is coauthor, with James Shreeve, of *Lucy's Child* (New York: William Morrow and Co., 1989). For additional reading about the Black Skull, he recommends *Origins Reconsidered: In Search of What Makes Us Human,* by Richard Leakey and Roger Lewin (New York: Doubleday, 1992) and also Grine's *Evolutionary History of the Robust Australopithecines.*



During a recent trip to the Falkland Islands, **Stan Osolinski** (page 86) was photographed with one of his new acquaintances. A native of Detroit, Osolinski recently moved to Bozeman, Montana, where he now enjoys watching the sun rise over the Bridger Mountains. He received his B.A. in philosophy and Latin from the University of Detroit in 1963 and taught gifted children for ten years, before switching to a career as a wildlife photographer. His interest in nature developed while working on projects to keep his students engaged. Osolinski quit his teachin job and began traveling to where the an mals were, first to the Florida Everglade and then to East Africa, where he has don most of his work. He says he would n trade jobs with anyone but admits that h would like to give stand-up comedy a tr Osolinski is now on an expedition to pho tograph tigers and one-horned rhinos i northern India. To photograph the zebra in this month's "Natural Moment," h used a Minolta Maxxum 7000 with 300mm Maxxum autofocus lens.



While researching collections of Ice e artifacts in American museums, **Ran-ll White** (page 60) came across dozens ornaments that had been little studied. is led him to explore the origins of per-nal adornment and the techniques used prehistoric peoples to work ivory and ner materials. An associate professor of thropology at New York University, nite served from 1986 to 1987 as the est curator of the American Museum of tural History's exhibition "Dark Caves, ight Visions." For additional reading, he ggests *The Creative Explosion,* by John eiffer (Ithaca: Cornell University Press, 85); *Before Lascaux,* edited by Heidi necht, Anne Pike-Tay, and Randall hite (Boca Raton: CRC Press, 1992); *sture and Speech,* by André Leroi-ourhan, translated by Anna Bostock rger (Cambridge: M.I.T. Press, 1993); d his own article, "Beyond Art: Toward Anthropological Understanding of the igins of Material Representation," in *nual Review of Anthropology,* vol. 21 992).





While pursuing his doctoral research on man evolution in East and Southeast sia, **Geoffrey G. Pope** (page 54) noted at Chinese scientists had discovered rly stone tools in the Nihewan Basin, a te that lies in a transitional region just rth of Asia's monsoon forests. Subse-ently, while on a study and lecture tour China in 1987, he learned that the site ight be opened to Western scientists. He ranged to visit the Nihewan for the first me the following year. Well traveled in Asia, Pope speaks Mandarin, Indonesian, and Thai. He is currently an assistant professor of anthropology at New Jersey's William Paterson College. For further reading he recommends *The Story of Peking Man,* by Jia Lanpo and Huang Weiwen (New York: Oxford University Press, 1990); *Archeological Remains in Pleistocene China,* by Jean S. Aigner (Munich: C. H. Beck, 1981); and *Early Man in China,* by Jia Lanpo (Beijing: Foreign Language Press, 1980).

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June 29 - July 15, 1993



By special arrangement, the American Museum of Natural History has planned an expedition for adventurous travelers to the land of Genghis Khan. In the company of American Museum scientists and Mongolian experts, you are invited to be part of a very small group that will take an in-depth look at present day Mongolian life, its history and important archeological finds. The highlight of our expedition is an unprecedented opportunity to spend two days with American Museum paleontologists conducting field work in the Gobi Desert. We have also planned our visit to coincide with the country's National Day celebrations in Ulan Bator, one of the most unusual and interesting National celebrations in Asia. A privately-chartered helicopter will provide the access and flexibility needed to explore this remote country.

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LETTERS

FLOWERS VS. MINES

Robert H. Mohlenbrock's article on Cushenbury Canyon ("This Land," February 1993) contains a number of incorrect statements and subjective opinions. He is wrong to state that mining "generates thirteen tons of waste material for every ton of ore produced." Waste-to-ore ratios vary; currently the combined limestone mining operations along the north slope of the San Bernardino Mountains produce less than one ton of waste rock for every three tons of ore. He also states that the "piles of overburden...are inhospitable to vegetation." Many such piles have spontaneously revegetated, some in as little as three years.

Mohlenbrock claims that five plant species (Parish's daisy, Cushenbury buckwheat, Cushenbury milk vetch, the San Bernardino Mountains bladderpod, and Cushenbury oxytheca) "have little chance of surviving continued mining operations." Less than 2 percent of the known habitat of these plants will be affected by future limestone mining. Several studies, including those done by the Forest Service, indicate that at many locations these plants naturally revegetate disturbed sites and sometimes grow more vigorously there, with a higher proportion of flowering individuals than at adjacent, undisturbed sites. Moreover, the plants in question are not restricted to limestone, as Mohlenbrock indicates. At least 34 percent of the known populations grow on other kinds of rock. Propagation studies at one mine site have shown that Cushenbury buckwheat and Parish's daisy readily grow in granite-derived road cuts.

Mohlenbrock asserts that mining and reclamation regulations are weak and poorly enforced. California, however, has the most stringent regulations of any state. Every aspect of a mining operation, including reclamation, is monitored by government agencies at federal, state, and local levels. Mohlenbrock is also wrong to argue that the 1872 mining law is out of date. Many laws on pollution and other concerns have kept it up to date. A claim can be patented only after a minable ore deposit has been proved to exist. To do s as well as to meet environmental requir ments and standards, the claimant ma spend millions of dollars in exploration the claim.

HOWARD J. BROW
Senior Geologi
Pleuss-Staufer (California) In

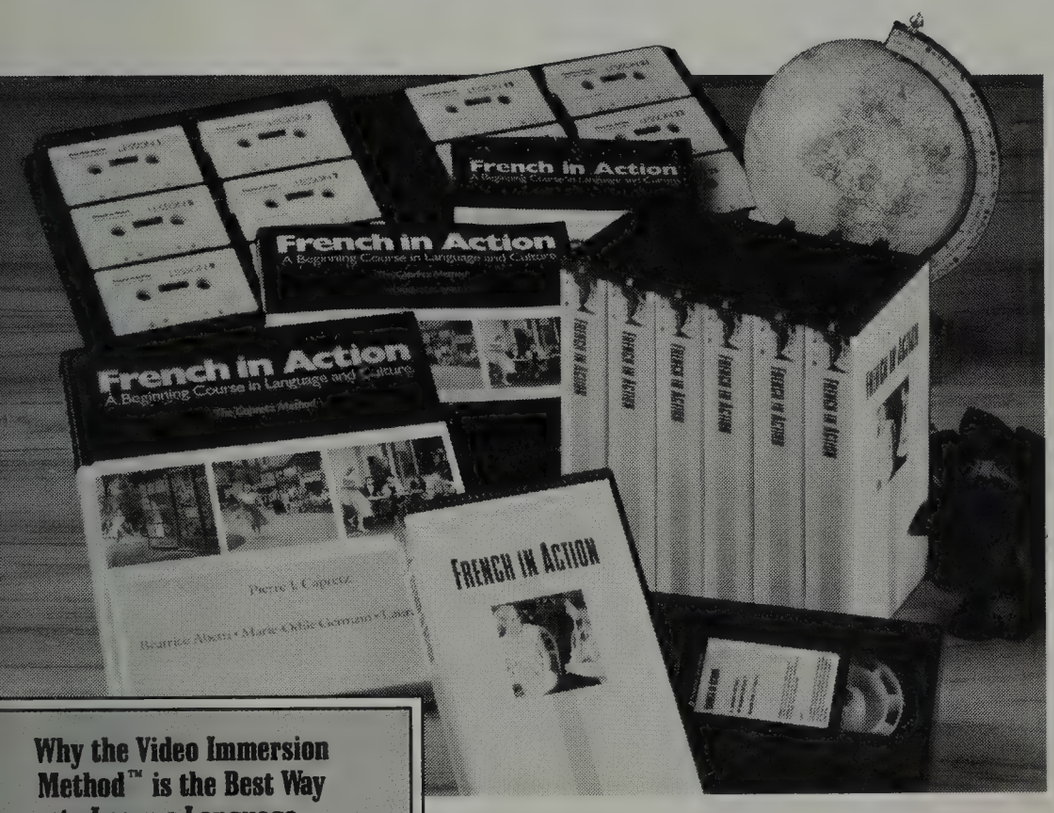
ROBERT H. MOHLENBROCK REPLIES:

Howard J. Brown is correct in sayin that waste-to-ore ratios vary and are ger erally lower than my figure, which repre sents the extreme. Nevertheless, accordin to an environmenal impact report prepare by the San Bernardino National Forest i 1992, the average is 4.9 tons of waste fo every ton of limestone used. Only a fe common, weedy plants become partly es tablished on the overburden. Not a singl limestone mining site in the San Bernar dino Mountains has been reclaimed by re planting with the original species.

Although Brown projects that less tha 2 percent of the known habitat of the rar plants will be affected by limestone min ing, in fact mining companies hold min eral patents on almost all the carbonat substrate, which by law implies an inten to mine. To say that the rare plants grow more vigorously and flower more prolifi cally in disturbed sites is spurious. Of the many disturbed sites in the San Ber nardino National Forest, only a very few are inhabited by the rare plants. These spe cies are found episodically after disturb ance, but whether they can maintain them selves is questionable, since the chemistry of the soil has been altered. In my article, was careful to indicate that these plants are "carbonate endemics," not "limestone en demics," so Brown's figure of 34 percent is not applicable.

The five species I singled out are per ceived as rare by the U.S. Fish and Wild life Service, the Nature Conservancy, the California Native Plant Society, and Jep son's new *Manual of the Higher Plants of California*. Reenactment of the Endan gered Species Act and reform of the 1872 mining act will be crucial to their long term survival.

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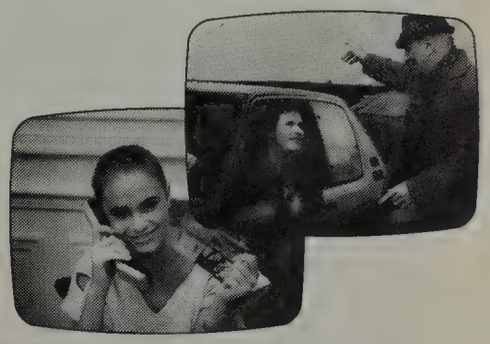
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The Bambi Syndrome

Disney's cartoon version of Felix Salten's novel forever changed American sentiment about hunting

by Matt Cartmill

Prospects look bleak for America's hunters. Only about 12 percent of Americans still hunt, and the percentage seems to be dwindling year by year. In 1982, Americans spent 109,000 hours hunting on U. S. public lands; by 1990, the figure had dropped to less than half that.

Part of this change probably reflects the shrinking population of small-town America, where hunting has always been a part of the rural way of life. But public attitudes are changing, too. Although most of us still think it all right to hunt for meat, many people oppose hunting for trophies or recreation. One poll shows that almost a third of all Americans feel sport hunting should be illegal. And that feeling is being promoted by organized antihunters, who are hard at work circulating petitions and propaganda, pressing for new laws and regulations to limit hunting, and even running through the woods in front of hunters to scare off their prey.

Each side in this confrontation sees the other as a congregation of lunatics. Pro-animal activists regard hunters as macho gun nuts eager to prove their manhood by drilling anything that moves. For their part, hunters view their opponents as sentimental fluffheads, who dream of the natural world as a happy Eden and idealize wild animals as little innocent people in bunny suits.

Many hunters blame this antihunting sentiment on Walt Disney. A lot of hunting writers seem to think it all began with the 1942 release of *Bambi* and that if this film and certain other Disney products could somehow be suppressed, opposition to hunting would evaporate. Warren Page, a former editor of *Field and Stream,* expressed this view in a 1973 speech:

> In this country we have undergone an entire generation of brainwashing. Not only our kids but our wives, our brothers, our mothers, our cousins, our brothers-in-law have for twenty-five years been subjected to constant film and TV presentations of the Disney myth. In the Wonderful World of Disney...the lion and the lamb love one another and only man is the bastard in the black hat...whose chief aim is the spilling of Bambi's blood. Now this is the Bambi Syndrome. The Disney films may not have started out that way, but once it became clear that sentimentality and outright anthropomorphism would make money, that's the way the films went.... They deliberately misinform viewers of basic biological facts.



Sculpture by Hilary Carlson, 1992
Richard Bachmann

Bambi bashing pervades the defensive protests of today's embattled outdoorsmen. "Too many antihunters believe in the Bambi quality of animals," writes sports columnist Jim Wilson. "Those animals don't procreate or eliminate wastes or eat one another, they gaily romp and play their lives away.... These people never knew or don't want to know that death is as quotidian in the wild as sucking air in and blowing it out."

The hunters are surely right about one thing: for all its saccharine sweetness and childish whimsy, Disney's *Bambi* is probably the most effective piece of antihunting propaganda ever made. It had a wide and deep influence on modern attitudes toward hunting, wildlife, and the wilderness.

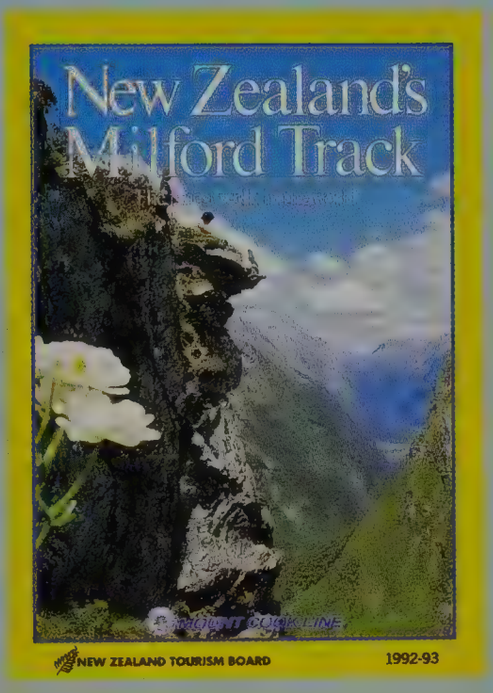
The Bambi myth was the creation of an ambitious young Hungarian writer named Siegmund Salzmann, who came to Vienna in the mid-1880s in search of fame and fortune. Changing his Jewish-sounding name to Felix Salten, he began turning out volume after volume of plays, stories, and criticism and quickly became a major force in Viennese literary circles. Salten's life, like those of many middle-class Viennese, seethed with public and private contradictions. A pillar of Establishment propriety on the surface, he was also the secret author of a notorious pornographic novel, *The Memoirs of Josephine Mutzenbacher.* An aristocratically contemptuous critic of American society and culture, he was also a Rotarian and the German trans-

Adapted from *A View to a Death in the Morning: Hunting and Nature Through History,* by Matt Cartmill. Published by Harvard University Press. ©1993, by Matt Cartmill.

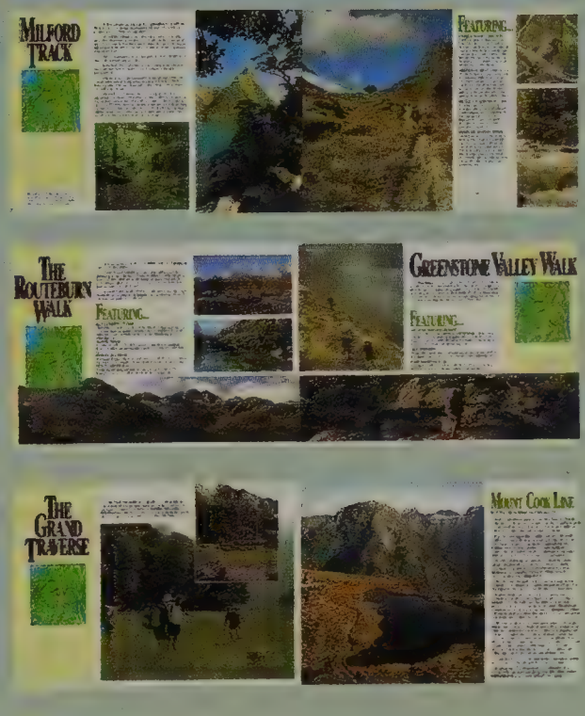
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lator of the long-running Broadway hit *Abie's Irish Rose.* He liked to go hunting with Hapsburg aristocrats and even owned a private hunting preserve of his own just outside of Vienna. But he was also an ardent animal lover, and his hunting experiences led him to produce a masterpiece of antihunting sentiment.

Salten's novel *Bambi: A Forest Life* appeared in 1924. Written in the decaying capital of the defeated and dismembered Hapsburg empire, in an intellectual atmosphere dominated by Freudian gloom and the increasingly hysterical voices of artistic and political extremists, the book radiates a cold aura of pessimism. "Death is the central theme of *Bambi,*" writes sportsman-conservationist George Reiger. "Something fears dying, or does die in terrible agony, in almost every chapter." The forest world that Salten describes in sometimes exquisitely poetic prose provides a backdrop of intense color and beauty in front of which his animal characters suffer and bleed and limp and die awful, uncomprehending deaths. Some of those deaths result from disease or predation, but these natural evils seem trivial compared with the terrors inflicted on the animals by the satanic two-legged demigod they call Him with a capital H. The young roebuck Bambi finds himself dodging bullets within seconds after his first glimpse of a human, and he staggers through the book watching one after another of his friends and relatives fall to hunters' guns.

Although Salten's tame animals revere humans as gods and the wild animals abominate them as demons, they all acknowledge human dominion over nature. "No one can escape Him," says one forest creature after another throughout Salten's book. "He kills what He wants.... He can do anything." "I worship Him, I serve Him," yelps a dog to a maimed fox. "He's all-powerful. He's above all of you.... Everything that lives or grows comes from Him." At the end of the book, this delusion is dispelled for Bambi when his dying father takes him to view the corpse of a murdered poacher. Bambi thereby learns the great secret: *Homo sapiens* is only another dying animal, and the governance of the world lies elsewhere.

The English translation of *Bambi* appeared in 1928. The translator was the young Whittaker Chambers, who had joined the Communist party not long before and was later to become famous as Richard Nixon's star witness in the Alger Hiss case. The English novelist and Nobelist John Galsworthy, a virulent opponent of hunting, contributed a foreword to the translation, calling Salten's book "a little masterpiece." Reviewers were ecstatic. "The author," wrote John Chamberlain in the *New York Times,* "has given us the life story of a forest deer, and Felix Salten's comprehension of the entire universe as well.... Throw away your Spinozan tomes on pantheism and read *Bambi.*"

Salten's books would probably be as little read nowadays as Spinoza's were it not for another event in 1928. That September in a New York recording studio, a young film maker named Walt Disney managed to get a sound recording of "Turkey in the Straw" synchronized with the movements of a cartoon mouse. As a result of this cinematic breakthrough, Bambi's name was going to become virtually synonymo with "deer," although neither Disney n Salten expected it yet.

Walt Disney was born in Chicago 1901. When he was five years old, h family left the city and moved to a farm Missouri. Disney always remembered t four years he spent on that farm as the ha piest part of his childhood, and the idyl farmyard and the animal friends he ma there turn up again and again in his film Significantly, one of his few unpleasa memories of the place involved hunting

When Disney's family arrived, th found the farm overrun with rabbits, a Walt crept into the fields with his old brother Roy to watch them in their sprin time mating rituals. Charmed and excit by all the March-hare antics, Walt spe the next few days memorializing them his very first cartoons: childish sketches cottontails playing peekaboo in the gras But when Roy next returned to the field he brought along his air rifle and shot th biggest buck bunny he saw. Walt dissolve in tears when Roy broke the thrashing ra bit's neck, and he refused to touch the ra bit stew their mother served up th evening. The contrast that this incide embodied between innocent animal desi and malign human contrivance was recur in several Disney films. He wou impress that love-and-death opposition o the world with particular force in *Bambi.*

Disney began his film career makin animated ads in Kansas City. Moving t Hollywood in 1923, he pressed towar heights that no one before him ha dreamed of reaching with animation Starting from the crude drawing and barn yard humor of the first Mickey Mouse ca toons in 1928, Disney and his artists too less than a decade to learn how to inspir pity and terror, as well as laughter, with twelve-per-second flow of talking-anima caricatures. Everybody, including the in tellectuals, went wild over the results. "A great many people," gushed film criti Gilbert Seldes in 1937, "consider Disne as the great satirist of the machine age."

Bambi posed serious challenges eve for the Disney studio. The Disney cartoo animals of the 1930s had rounded outline and a rubbery consistency, which mad them easier to draw and gave their move ments the conviction of exaggeration They were drawn as bipeds with human hands, so that the animators could use ges tures to express the characters' emotions When Disney selected *Bambi* for his sec ond animated feature, he knew that these habits had to be abandoned. What Salten

Hunter, Gatherer, Barbecuers





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was saying about life, death, suffering, and God could not be put in the mouth of a cartoon deer that looked like Clarabelle Cow with antlers. To give the animated deer the potential for tragedy, an unprecedentedly realistic set of drawing conventions had to be developed. The *Bambi* animators were told that they could use whatever human expressions they could impose upon the stiff, elongated face of a deer, but human-looking postures and movements were forbidden. The animators gritted their teeth and began imagining themselves into the bodies of deer, learning to express human feelings with shifts in weight support and gait patterns, with head and neck posture, with flicks of the ears and tail.

Work on the script began in 1937. The first story treatments were frivolous pastiches of cornball dialogue and Silly Symphony sight gags. But during 1938 and 1939, as the clouds of war gathered in Europe and the Pacific, the script drafts grew increasingly tense and despairing and began to center on human cruelty and violence. On September 1, 1939, the day that German tanks struck across the Polish border and plunged Europe into World War II, the film's story editor Perce Pearce announced that all predators other than *Homo sapiens* had to be excised from the script. "There's nobody swooping down and eating someone else and their one common enemy is Man. That's the conflict there—and keep it simple."

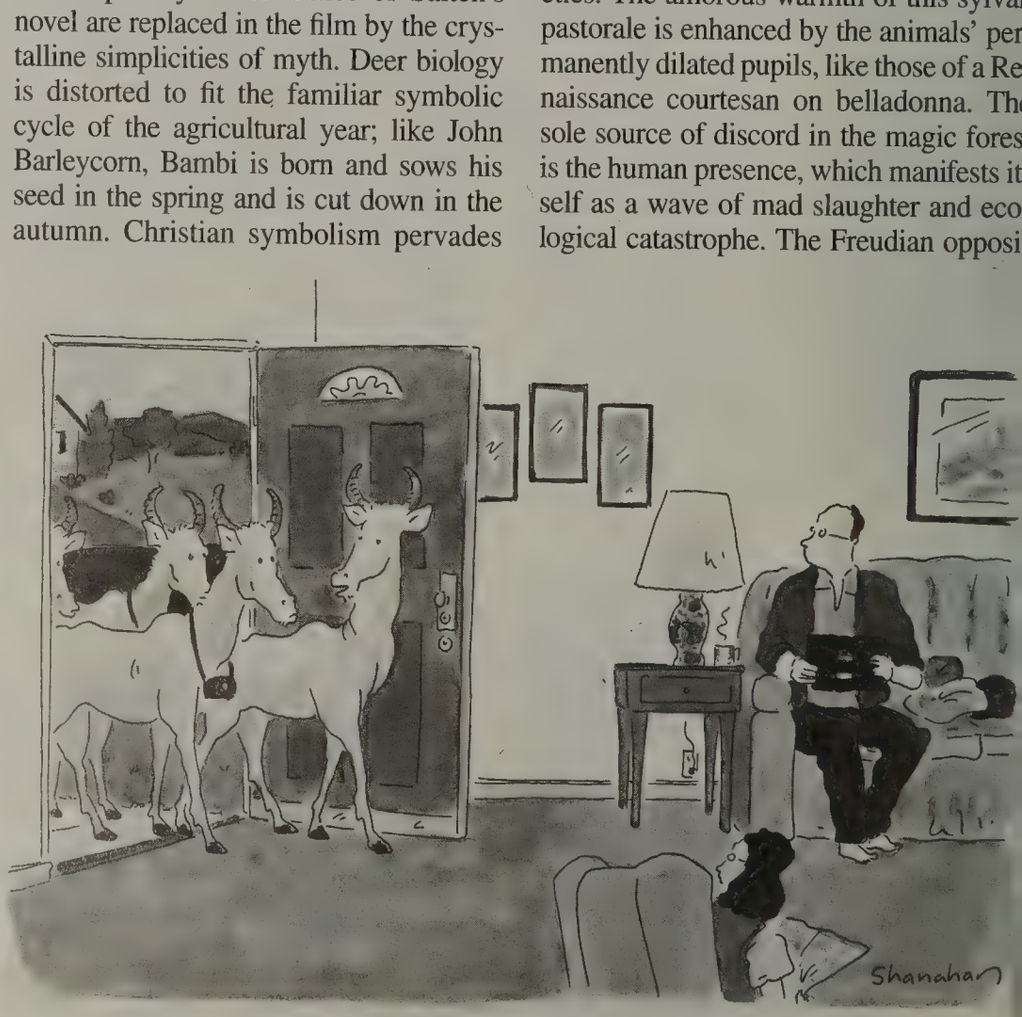
The first reasonably complete script treatment for *Bambi* that survives was written near the end of 1939. It is saturated with bitter detestation of human beings and their weaponry. The fawns Bambi and Faline are shot at (but missed) as they play in a sunny meadow. The deer gather for a colloquium on human depravity. "Whenever man comes into the forest, there's nothing but fear!" cry the animals. "He kills without mercy!" Bambi's mother declares her faith in the possibility of human love. A little later, she and Bambi are stalked by a hunter. They flee, but a shot rings out; we see her jerk in midleap and fall dead. As Bambi wanders the forest crying for his lost mother, he hears what he thinks is her voice and runs toward it joyously—to discover a hunter with a deer call, who shoots him. Bleeding and gasping with pain, Bambi staggers back to the thicket where he was born. He begins calling for his mother again and falls down, apparently dead. His anxious father arrives to watch over him until the unconscious fawn begins to breathe once more.

Humans reenter the forest after Bambi has grown into an antlered buck. Hunting dogs run in the vanguard, praising human omnipotence and tearing cornered animals to bits. Friend Hare, the prototype of Thumper, intercepts a bullet and dies at Bambi's feet, murmuring, "I don't understand—What have I ever done to Them?" After a fire set by the intruders devastates the forest, Bambi's father leads him through the smoldering ashes to a man's charred cadaver, revealing the great secret of *Homo sapiens*' animal nature. The film ends in a scene of rebirth, with the forest sprouting anew and Bambi glimpsing Faline with two newborn fawns.

In succeeding drafts, the script grew simpler and sweeter, and the animals' assessments of the human condition were deleted one by one, until no dialogue remained to establish their superstitious awe of humanity. The climactic scene with the cooked cadaver was reluctantly dropped from the film in the last stages of production, and with it went the last vestiges of Salten's attempted reconciliation of human beings with nature. The only remaining discussion of the human presence is Bambi's question, "What happened, Mother? Why did we all run?" and Mother's slow, portentous response: "Man…was in the forest."

The prickly uncertainties of Salten's novel are replaced in the film by the crystalline simplicities of myth. Deer biology is distorted to fit the familiar symbolic cycle of the agricultural year; like John Barleycorn, Bambi is born and sows his seed in the spring and is cut down in the autumn. Christian symbolism pervades the film's opening scenes. After the ado ing animals finish hailing the birth of th young prince and depart, the camera pul back to show mother and child nestled in thorny thicket—a tableau that story edit Pearce referred to as "that madonnalik picture"—while a remote, godlike fath looks down from a heavenly crag.

Contemporary psychoanalytic gim micks also made their way into *Bamb* The first English translation of Jung's *A chetypes of the Collective Unconsciou* appeared in 1939. Late in that year, th Disney conception of Faline abruptl changed from a shy fawn to a teasing, se ductive minx who repeatedly shows up a a double of Bambi's reflection in the wate All this bears a suspiciously minute re semblance to Jung's description of hi "anima" archetype. Freudian motifs ar also prominent in the film. As one migh expect of an intellectual in Freud's Vienna Salten had put plenty of Oedipal conflic into his book, and the Disney peopl picked up on it. Bambi's film father i strong, scary, and forbiddingly distant, an the tension between them is resolved onl by the wrenching death of Bambi' mother. The film portrays the natura world as a realm of peace and beauty, sat urated with innocent love in all its vari eties. The amorous warmth of this sylva pastorale is enhanced by the animals' per manently dilated pupils, like those of a Re naissance courtesan on belladonna. Th sole source of discord in the magic fores is the human presence, which manifests it self as a wave of mad slaughter and eco logical catastrophe. The Freudian opposi



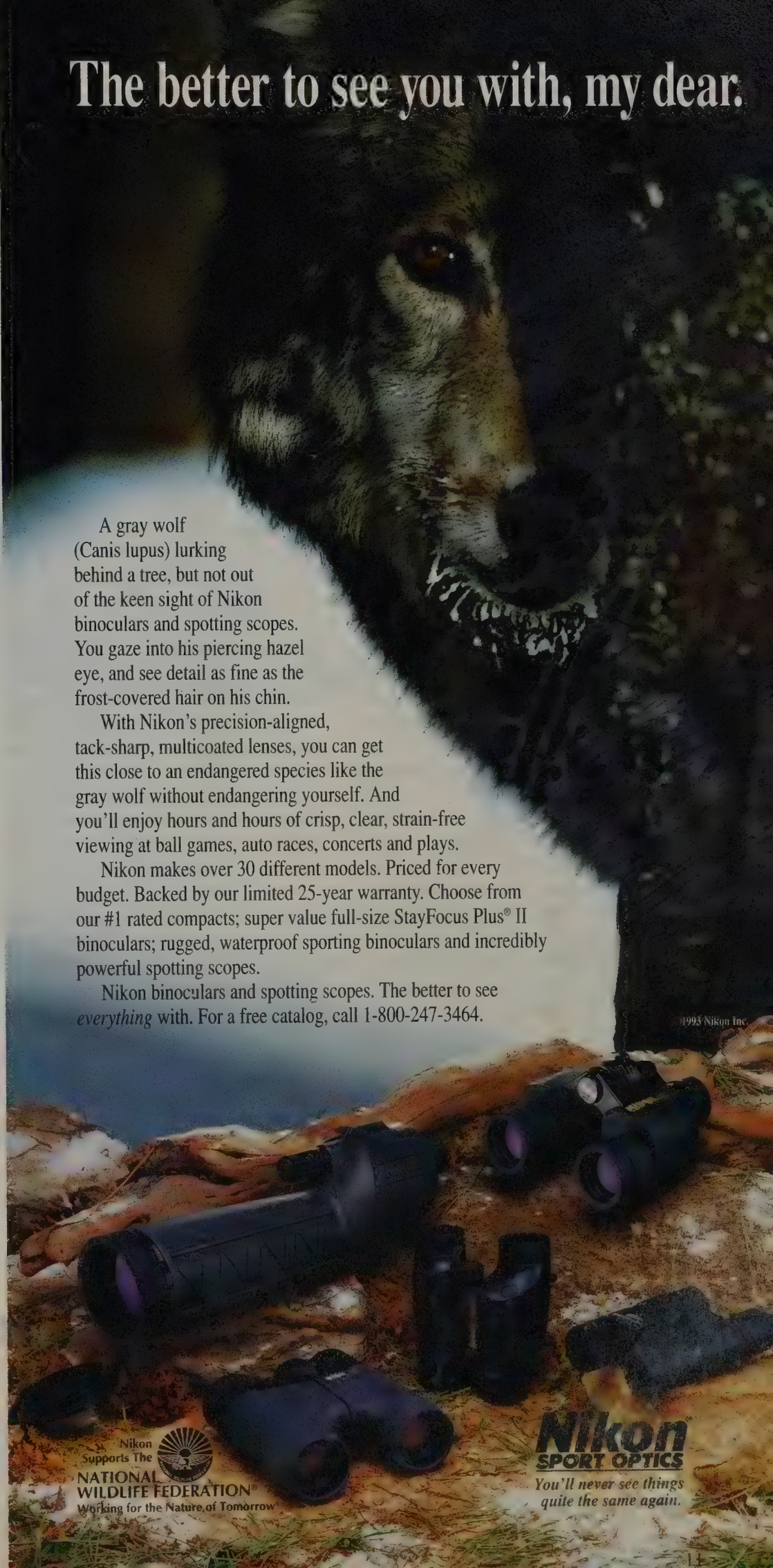
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n between the instincts of life and death equated throughout the film with the mbolic opposition of humanity to na-e, and no possible resolution of the con-ct is hinted at.

Conflict between humanity and nature mirrored even in the film's musical ore. Like *Fantasia, Bambi* is essentially ilent movie: a wordless, rhythmical bal- performed to an orchestral accompani-ent. (The final script contains less than a ousand spoken words.) The alienation of e human species from the natural order symbolized by barring the human pres-ce completely from the universal dance. uman beings are represented only by inous, lurching music that—unlike the st of the score—is unaccompanied by screen choreography.

All these psychological and symbolic vices chugging away in Disney's *ambi*—its archetypal characters, its eudian machineries, its invocations of ristian and pagan mythology, its per-ctly choreographed universal dances of things not human, its A-B-A architec-re silently proclaiming the eternal recur-nce of nature, its superbly executed ani-ation, its occasionally breathtaking sual beauty, and its despairing sublimi-l consciousness of the implacable on-sh of World War II—give the movie the rce of a sledgehammer for many view-s, despite its pervasive and repellent teness. "I came out of *Bambi* on my nds and knees," recalled director ichard Williams in a 1989 interview. Re-ewing *Bambi* when it was rereleased in 988, critic Roger Ebert described it as "a arable of sexism, nihilism, and despair, ortraying absentee fathers and passive others in a world of death and violence," nd called it unsuitable for young and im-ressionable children.

The first attack on *Bambi* by America's utdoorsmen came in 1942 from Ray-ond J. Brown, the editor of *Outdoor Life.* enouncing the movie as "the worst insult ver offered in any form to American portsmen," Brown complained that *ambi* showed hunters engaging in such nsportsmanlike practices as killing a doe nd hunting deer with dogs. Now hunters' ttacks on *Bambi* are, if anything, more rident and insistent, but they no longer riticize it as a slur on the honor of sports-nen. The line commonly encountered owadays is that the movie is nature-fak-ry, a fantastic distortion of the facts about ne behavior of wild beasts, and that chil-ren who see it are misled into a foolish entimentalism about wildlife.



American hunters, who tend to cluster toward the political right, have also picked up the scent of Marxism and atheism in *Bambi.* In a 1980 article in *Field and Stream,* George Reiger argues that Salten wrote *Bambi* out of a pious liberal revulsion against the carnage of World War I, and Chambers was attracted to it because of his Marxist inability "to accept the impersonal realities of nature." But in Reiger's eyes, what Disney himself "and his staff of little helpers" are guilty of is not Marxism but blasphemy—specifically mockery of Christ. Reiger complains that "in Disney's version, once Bambi is raised in status from mere deer to Jesus Whitetail Superstar, man's hunting of deer becomes a crime comparable to the persecution of Christ."

Is there any truth in what these writers say about the Bambi syndrome and its importance? Certainly none of the things that hunters object to in the film originated with Disney. The vision of the wilderness as an Eden and of man as a destructive intruder into the harmony of nature extends back into classical and medieval thinking. Wounded deer have for centuries personified injured innocence. They are common symbols of the crucified Christ in medieval literature; one fourteenth-century German poet described Jesus as a hunted stag "whose hoof is stained with blood, for He ransomed us at so great a price." Moral indignation over hunting flared up now and then even in antiquity and has become steadily more commonplace in Western culture since the Renaissance. The notion that all this is Walt Disney's fault is wishful thinking on the part of Reiger, Page, and other outdoorsmen.

Yet if Disney did not invent the symbolism that portrays hunted deer as ravished maidens and martyred Princes of Peace, he gave it a mass audience, an irresistible graphic expression, and a mythical embodiment that it would not otherwise have had. Bambi has become emblematic of deer in general. Stand for an hour or two in front of a deer pen at a zoo; some child or its mother is sure to point to a deer and exclaim, "Look! Bambi!" (I have heard the name applied to sika, axis, white-tailed and mule deer, as well as to various more or less gracile antelopes, up to and including the big, cowlike nilgai of India.) Even some jocular hunters like to call their quarry "Bambis." Bambi seems to be on his way to becoming a lower-case noun, as his predecessor Reynard the Fox did in the French language.

As the stereotypic deer, Bambi symbolizes all those things we associate with deer, including doe-eyed innocence, wilderness, and the natural order. (When James Watt became U. S. Secretary of the Interior, editorial cartoons showed the forest animals shouting, "Run, Bambi, Run!" and comedian Mark Russell announced that Bambi was leaving for Canada.) Some historians of forestry think that the forest-fire sequence in *Bambi* was what drove the U. S. Forest Service to launch a no-burn policy two years later. *Bambi* also had an important influence as the prototype for Disney's True-Life Adventures of the 1950s. Two central conventions of those pioneering wildlife films derive from *Bambi.* One is the eternal recurrence, in which a final return to the starting place marks one round of nature's ancient and unchanging cycle. The other is the exclusion of the human image from the picture—and, by implication, from the kingdom of nature.

Even hunters fall prey to the Bambi syndrome. One ex-hunter interviewed by the writer John Mitchell for his book *The Hunt* admitted that his attitude was changed by his two daughters, who "got the idea every deer is named Bambi. And I began to wonder what is sport and what isn't." In the last paragraphs of his book Mitchell tells of the moment when he gets his own first buck centered in his rifle sights. Suddenly, he stops, ejects his cartridge, and collapses, trembling uncontrollably after staring into "the eyes—the huge glistening eyes that had torn my own away from the cross hairs on the shoulder." In a 1982 *Smithsonian* article Mitchell frankly blamed his shakes on *Bambi*: "Walt Disney got to me early.... I wept for Bambi when the huntsmen slew its mamma; yet today I count deer slayers among my closest friends, and...occasionally join them afield, bearing arms. But I have never shot a deer, or at one."

Bambi and other Disney films had a profound impact on American attitudes toward hunting, wildlife, and nature. Today, fifty-one years since the first release of *Bambi,* they continue to have a similar impact on children and adults alike, and their influence is sure to be strengthened by the videotape revolution that has put copies of these movies into millions of American homes. These Disney products have been influential not only because they are effective theater but also because they express thoughts that we are predisposed to think for other reasons. Much of their force derives from our vision of the natural world as a special, mystical realm from which human beings are alienated by their culture and technology. That vision was not dreamed up in the Disney studios. It has deep roots in the Romantic rebellion against scientific materialism, and its branches extend into just about every aspect of twentieth-century thought, from psychoanalysis to postmodernism.

Ironically, that same vision is also central to hunting as we define and understand it. The line we draw between the human world and nature is what separates wild from domestic animals and thereby distinguishes the hunter's craft from the butcher's. When hunters say, as many do, that they go hunting to restore their sense of oneness with nature, they are at bottom expressing the same sort of sentimental reverence for "nature" that underlies the Bambi syndrome. □



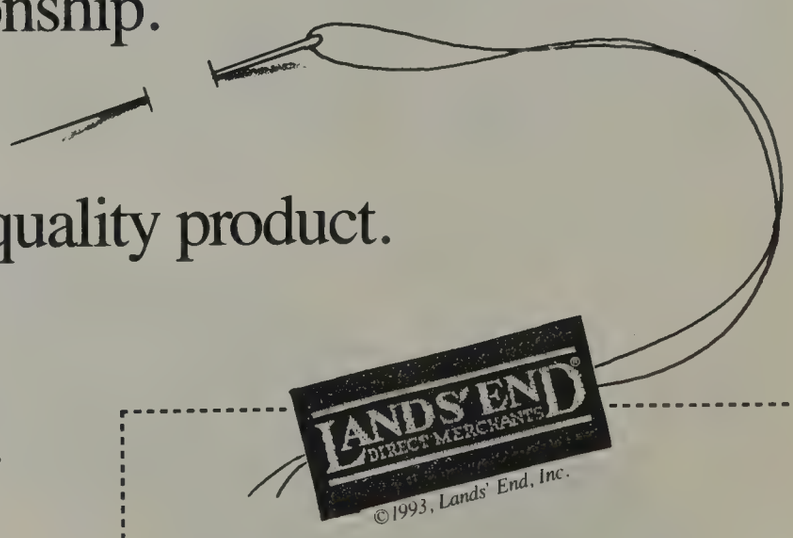
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The Invisible Woman

In the past, even great female naturalists gained little more recognition than a passing nod in a preface

by Stephen Jay Gould

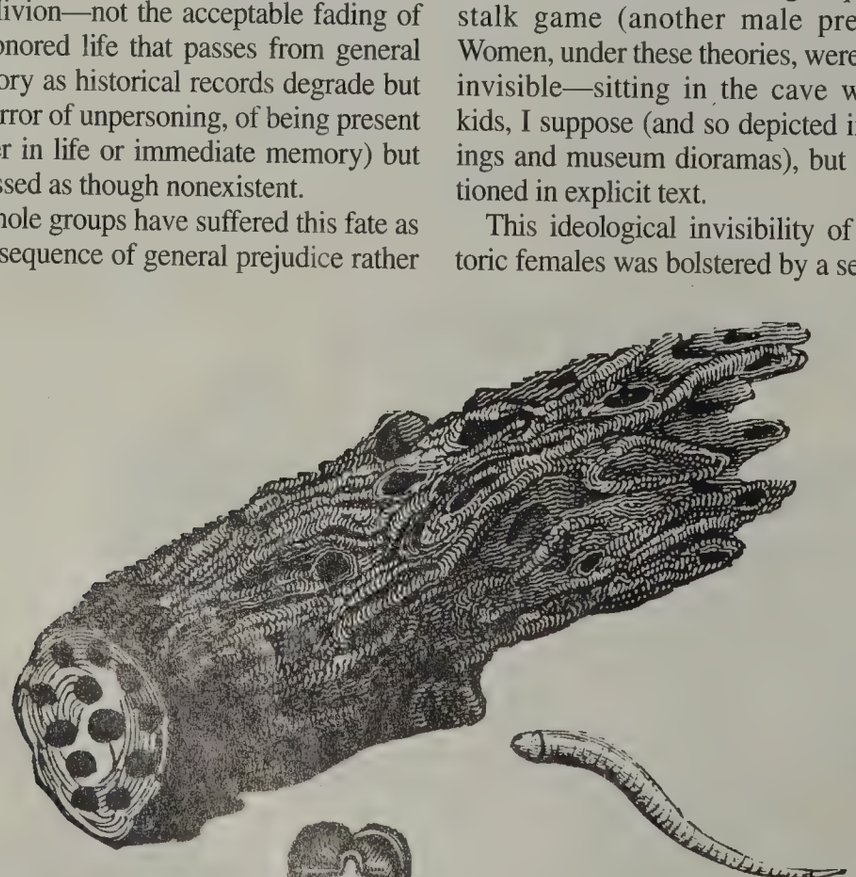
Following Khrushchev's revelations of Stalin's less than saintly persona and procedures, the Soviet Union revised its official version of Communist Party history during the twentieth century. I bought a copy of this new edition and immediately turned to the index to learn the latest word on Uncle Joe. I found that he had suffered the worst of all fates: he simply wasn't there. And I thought to myself: love him or hate him, but how in hell can you tell the story of twentieth-century Russia without him? The keepers of official records had used the primary device of excommunicators, anathematizers, and ostracizers throughout history: there is a fate far worse than death or the rack, and its name is oblivion—not the acceptable fading of an honored life that passes from general memory as historical records degrade but the terror of unpersoning, of being present (either in life or immediate memory) but bypassed as though nonexistent.

Whole groups have suffered this fate as a consequence of general prejudice rather than special excoriation. As a primary example from my own field of evolutionary reconstruction, nearly all older theories for the "ascent of man" limited their concepts by the same prejudice that set their choice of words. Until the feminist movement provoked a salutary expansion to the entire human race, nearly all theories attributed our shared capacities for language, intelligence, and other valued properties of mind entirely to the activities of prehistoric males. Thus we learned that language arose from the coordination needed to hunt large animals (an all-male activity in conventional reconstructions) or that consciousness itself emerged from the more complex mental functioning required to stalk game (another male preserve). Women, under these theories, were simply invisible—sitting in the cave with the kids, I suppose (and so depicted in paintings and museum dioramas), but unmentioned in explicit text.

This ideological invisibility of prehistoric females was bolstered by a sexist sociology of disciplines that prevented livin women from practicing the most prest gious parts of science—research and pub lishing. Only in this generation hav women been entering science in substan tial numbers. (I am proud that my own la has included 50 percent or more of wome graduate students during the past decade but I must admit that the first woma teaching fellow in our largest genera course for nonscientists did not obtain he position until the early 1970s; she is now distinguished researcher at the Smithson ian Institution.)

If intellectual women have been so re stricted in our own day, consider the ever greater limits imposed during the nine teenth century, the subject of this essay. I England, women were excluded from most major scientific organizations. The Geological Society of London did no admit women until 1904 (T. H. Huxley, to his discredit, had strongly supported the ban), the Linnean Society until 1919. Women fared better in botany, a subject considered suitable to the tastes and sensi bilities of a "weaker sex." But even here the reasons for limited acceptability took root in discrimination and fostered no egalitarian flowering. In an admirable study of "The Woman Members of the Bo tanical Society of London, 1836–1856" (*British Journal for the History of Science*, 1980), D. E. Allen wrote:

> Botany could break the rules because it had the great good luck to be in keeping with both of the contemporary alternative ideals of femininity. On the one hand it was able to masquerade as an elegant accomplishment and so found favor with the inheritors of the essentially aristocratic "blue-stocking" creed, with its studied cultivation of an unintense intellectualism. On the other, it passed as acceptable in those far more numerous middle-class circles which subscribed to the new cant of sentimentalized womanhood: the "perfect lady" of a repressive Evangelism.



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Even so, women played only a subsidiary role when admitted. The Botanical Society of London began in 1836 with some 10 percent female membership, but the proportion dropped and remained at about 5 percent during the society's twenty-year life. Only one woman ever contributed a paper to the society's meetings, although she did not read the work herself but enlisted a male member as a surrogate for the occasion. No woman was ever elected to the council or served as an officer of the society. Women members could vote at meetings, but only (as the rules stated) after "having previously informed the secretary in writing of their appointment of some gentleman, being a Member of the Society, as their proxy for the occasion." Finally, the Botanical Society was, itself, an iconoclastic organization, and the more established scientific institutions continued their total ban. Allen writes:

> The Botanical Society...was one of that tangle of minor bodies which had gradually been springing up to cater for the large under-class of the scientifically inclined who, even if they had the intellectual attainments, could on social grounds scarcely hope for election to the major societies. In short, it was an organization of outsiders. And like its fellows, it reflected this in a self-consciously liberal stance that verged on radicalism.

Women with scientific interests were therefore confined to a narrow range of marginal activities, away from (or, at best, auxiliary to) the centers of prestige and innovation in research and publishing. Women could illustrate works written by men. The plates for John Gould's *Birds of Europe,* second only to Audubon in desirability and cost for modern book collectors, were drawn largely by his wife, who therefore deserves most credit for the work's reputation—a consequence of the figures, not the text. Incidentally, many of the other plates were done by Edward Lear, one of Europe's best scientific illustrators by profession, but better known to us today for his nonsense verse.

Women could be collectors of specimens that were then turned over to men for formal description and publication. The beginnings of British vertebrate paleontology in the early nineteenth century owe more to the premier collector of this or any other age, Mary Anning of Lyme Regis, than to Buckland or Conybeare or Mantell or Owen or any of the men who later wrote about her ichthyosaurs and plesiosaurs. The greatest collector of marine algae, Mrs. A W. Griffiths of Torquay, was warmly praised by the man who then wrote the most popular work on seaside botany: "She is worth ten thousand other collectors; she is a trump." Charles Kingsley stated that British marine botany would scarcely exist without her and, in a revealing choice of words, lauded her "masculine powers of research." Yet, as Lynn Barber writes in her excellent account of British popular science (*The Heyday of Natural History, 1820–1870,* Doubleday, 1980):

> One genus and several species of seaweed were named after her, and she is mentioned with respect—almost with awe—by every Victorian writer on seaweeds, but she published nothing in her own name, and now survives only as an acknowledgment in other people's prefaces.

But the most public pathway for women lay in the writing of popular works in natural history—but only of a definite and characteristic genre: the saccharine and sentimental exaltation of nature's objects as illustrations of divine goodness and as guides to human reverence and proper behavior. Scores of women wrote an astonishing variety of such books, now almost totally forgotten, but then a conspicuous and profitable staple of publishing. These works are easily dismissed, as even Lynn Barber did in a sharp passage within a chapter devoted to praising those of her gender who persevered in science despite the obstacles:

> Unnumbered tribes of Victorian ladies seem to have written without ever doing an iota of research. Ladies were next in line to clergymen as relentless producers of popular natural history books, able at the rustle of a publisher's contract to launch into endless stories about...faithful dogs who rescued their masters from everything under the sun, and elephants Who Never Forgot. Most of their effusions were directed to other ladies, or to children (it is often hard to tell which) and characterized by glutinous sentimentality...and an ability to drop into verse at the least provocation.

I do not dispute Barber's assessment, but I believe that we must take this genre more seriously for many reasons, ranging from the scholarly (for insights provided into the history of women's social and intellectual struggles) to the ethical (respect due to marginalized people who bridle and suffer under imposed limitations but who, even on pain of illustrating a stereotype, must find some expression for creative impulses—blacks who preferred opera but entered the only available world of popular music, Jews like my grandfather who wished to be artists but ended up as skilled garment makers). I am happy to note that several scholars, particularly in feminist circles and programs for women's studies, are now rediscovering the invisible women who wrote popular books in natural history during the nineteenth century. I do not have the knowledge or experience to make a professional contribution in this specialized area, but I wish to record a personal encounter.

I recently purchased, at the decidedly low-priced end of a catalog from Britain's major purveyor of antiquarian books in natural history, a copy of a quintessential representative of this genre—*The Conchologist's Companion,* 1834 edition, by one Mary Roberts. I had not heard of it or her, but I was intrigued because I am a conchologist (a student of mollusk shells by specialty and because I wanted to learn about this once important but now invisible genre.

As I tried to discover Ms. Roberts, I quickly encountered the bugbear of all scholarly research into the activities of people declared peripheral by society's gatekeepers to intellectual prominence. Such people are nearly invisible today. Nobody wrote about them during their lives, and they never became subjects for later historians. We are often left with the meager evidence of parish birth records, publishers accounts, and epitaphs.

Mary Roberts wrote a dozen books on natural history, some apparently quite popular in her day, but she wins no more than a column in any biographical source. She was born in London in 1788, the daughter of a Quaker merchant (a common religious affiliation for women writers in Victorian times). Her family moved to Gloucestershire in 1790, but she returned to London (and left the Quakers) after her father's death. She lived in Brompton Square, London, for the remainder of her life, never married, and died on January 13, 1864. I have been able to find absolutely nothing else about her life. The most common observation, mentioned by all five of our sources, is her frequent confusion "with another Mary Roberts, 1763–1828...who dedicated to Hannah More an ambitious collection of poems." Such are the inevitable fruits of invisibility (and a common name).

The biographical sources also say almost nothing about the content of her work, beyond listing titles—although this evidence is potentially available (if also hard to get, for few libraries maintain col-

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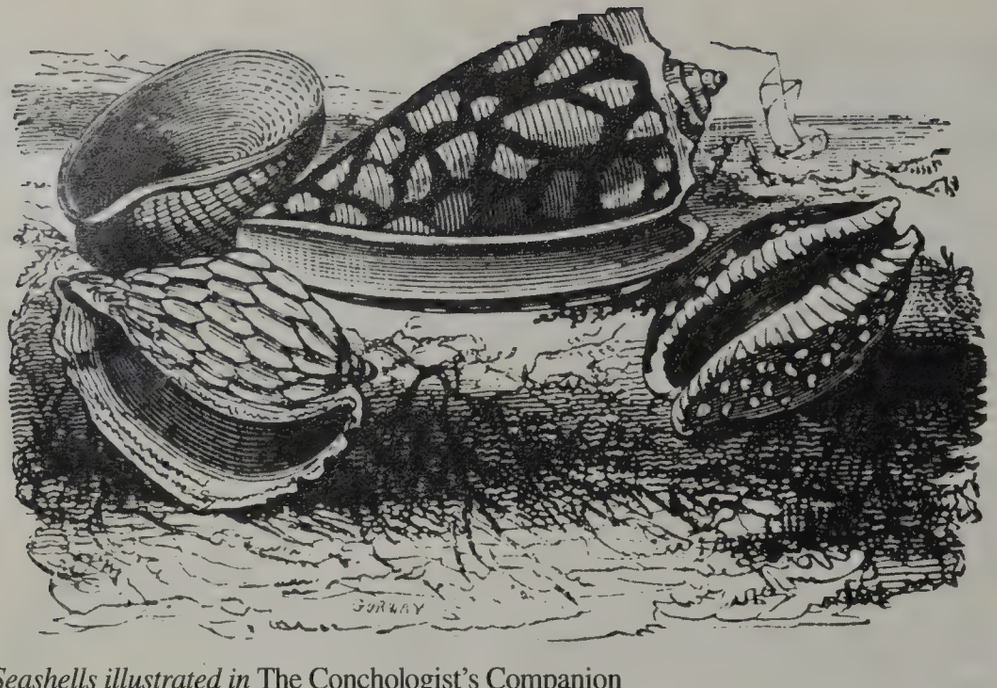
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Seashells illustrated in The Conchologist's Companion

lections in popular writing of past ages). My oldest source, *A Critical Dictionary of English Literature,* from 1870, refers to Mary Roberts as "a useful and popular English authoress." My latest, *The Feminist Companion to Literature in English,* from 1990, notes that "even when writing for young children, she carefully names her sources." She wrote some nonscientific books, most notably a compendium on lives of famous women entitled *Select Female Biography* (1821), and an 1823 work with the intriguing title: *Sequel to an Unfinished Manuscript of H. Kirke White's to Illustrate the Contrast Between the Christian's and the Infidel's Close of Life.* But most prominent are her dozen or so works in popular natural history, including (in chronological order): *The Wonders of the Vegetable Kingdom*; *Annals of My Village, being a Calendar of Nature for Every Month in the Year*; *Domesticated Animals Considered With Reference to Civilization and the Arts*; *Sister Mary's Tales in Natural History*; *The Seaside Companion*; *Wild Animals*; *Sketches of the Animal and Vegetable Productions of America*; *Ruins and Old Trees Associated With Memorable Events in English History*; *Flowers of the Matin and Evensong, or Thoughts for Those Who Rise Early in Prose and Poetry*; *A Popular History of the Mollusca*; and (my favorite title) *Voices from Woodlands, Descriptive of Forest-trees, Ferns, Mosses and Lichens.*

I cannot deny that *The Conchologist's Companion* is as conventional as conventional could possible be—as conservative, as mainstream, as establishment, as comfortable to all expectations, both of general argument and of particular style, expected from woman authors. (I do sense the contradiction implied by stating that work in a marginalized genre can be mainstream in content, but ideology and respect are different phenomena, and we all know only too well the phenomenon of the slave who lustily mimics his master's voice.)

The conventionality of argument helps us to grasp a superseded conceptual world in which God made all of nature in beauty and harmony, as an illustration of his power and goodness, and to provide the crown of his creation (us, of course) with a bounty of food, fuel, clothing, gems, and building material. A documentation of this system also helps us to understand, in an immediate and visceral way, the depth of the intellectual revolution promulgated by Darwin and his theory of evolution by natural selection.

Nature, to Mary Roberts, is pervaded by divine purpose; every organism works in harmony with all others toward the general good:

> All the various parts of nature are beautifully designed to act in concert. We see the hand of God employed in forming the lowest, and frequently, in our opinion, the most despicable creatures; assigning to each its station, and so admirably adjusting the mighty whole, that every particle of matter, and every living thing that creeps, or moves, upon the surface of the earth, is formed in subserviency to the general good.

God is so attentive that he even created some animals as food for others, being careful to locate them in accessible places. Mollusks exist, in part, to feed higher creatures:

> Some inhabit ditches and stagnant waters where they afford a constant supply of food to such birds as frequent their banks; others no doubt with the same benevolent design incrust marine plants in sandy barren places, near the sea; a large proportion remain concealed in the deep recesses of the ocean, where they furnish food to the finny tribes; others adhere to floating sea-weeds and abundantly supply the wants of marine birds; and, lastly, exotic snails abound in many uncultivated regions of the globe where they frequently afford a welcome repast to the fainting traveler.

Roberts illustrates the principle of universal goodness and teleology by the standard device of taking an apparently harmful creature and demonstrating its actual contribution to the general good (and to specific human benefit). Teredos, or wood-boring clams (commonly called shipworms), seem to be noxious in their destruction of ships, piers, and pilings. But look again to a wider beneficence. First of all, they bore very carefully, in a mode divinely calculated to cause minimal harm (I confess that for all my vaunted desire to approach the past in its own terms, without ridicule born of current knowledge, this passage did make me howl):

> But mark the protecting care of Providence. The destructive operations of these insidious animals are in a great degree obviated by the singular fact of their generally perforating the wood in the direction of the grain.

Moreover, by reducing logs and clumps of vegetation to sawdust, teredos prevent the clogging of rivers and flooding of land. Finally (and here I howled even more), teredos "open a source of considerable riches to the inhabitants of Sweden" by "employing the vigilance of the Dutch." For the teredos, you see, force the Dutch to keep their dikes and ships in continual repair, thus requiring "a perpetual demand for oak, pitch, and fir," largely supplied by Sweden—and so, "these apparently pernicious insects are continually at work at Amsterdam, for the advantage of Stockholm." Roberts therefore concludes:

> Cease then, my friend, to regard this creature as decidedly obnoxious.... The Creator has assigned it an important station among his works. The evil which it produces, is readily obviated by a little care and contrivance; but the good which it is appointed to effect, is incalculably great in the mighty scale of universal nature.

All aspects of nature illustrate and glorify God, even those features that seem to contradict each other. We may think that God made the pretty colors of shells for his



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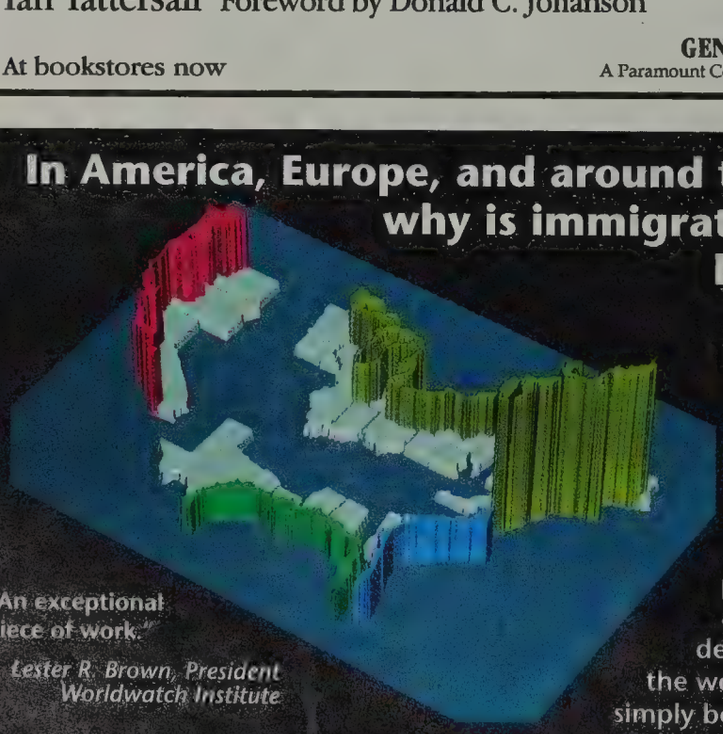
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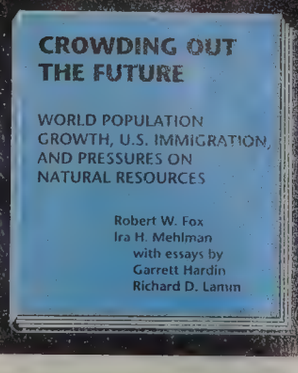
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(or our) delight, but they actually produc cryptic patterns that camouflage mollusk from their enemies:

But why, illustrious naturalist, did your ob servations extend no further? Saw you noth ing in these…shells, but an arrangement o colors to please the eye.… Saw you not, tha the Almighty Creator of the universe, with out whose permission a single hair does no fall from our heads, nor a sparrow fron heaven to the ground, nor a shell, nor a peb ble, is tossed with the billows on the shore by investing them in these simple col ors…provides against their utter extinction by the depredations of sea-birds and rapa cious fishes.

But in other passages we learn that Go did make colors only for beauty, and that as such, they stand in contrast to the utility of shell shapes and sizes. Roberts argue for adaptation in the shape and ornamen of the pholad (rock-boring clam) shell, bu for decoration alone in the color:

An ovate or oblong form is consequently th very best that could be adopted; and, more over, the points with which it is covered an adorned, are evidently designed to protec the shell from external injury.… At th same time a beautiful variety of tints evinc that minute attention to the finishing an decorating of his works which the Deity s continually displays.

Finally, nature is not only well designe and full of beauty; she is also replete wit moral messages for human betterment The metamorphosis of butterflies symbol izes the liberation of the soul from a earthly body, while the unfolding of flower represents our hope for mental en lightenment:

The botanist confesses, in the unfolding o the calyx…an attractive emblem of the ex panding of the human mind, as it emerge from a state of ignorance…or in the gradua development of a plant, the progressive ad vancement of every moral excellence.

Roberts's conventionality of argumen is fully matched by her faithful adherence to the style of presentation expected from women authors in this genre. When, fo example, she discusses the utility of mol lusks in human life, she emphasizes sup posedly "feminine" themes of adornment rather than "masculine" motifs of immedi ate sustenance. Her longest chapters trea pearls and purple dyes (classically ex tracted from snails), but she barely men tions the fact that many people eat clams and snails.

More important, and now getting closer to the bone of our urge to render judgment even across centuries, Roberts invokes the

tative hierarchy and stability of nature argue that each of us must accept our pointed role in human society, even if e be placed at severe disadvantage by ac- dent of birth as a female or as a member the working classes. Our ultimate re- ard, after all, is not in this world. Just as od has designed each species of mollusk r its appropriate environment, he has

signed to every individual being, his re- ective sphere of action; and happy will it for us, if we as steadily perform our por- on of allotted duty, as these feeble crea- res fulfill the purposes for which they are signed, in accordance with their respec- ve instincts.

Later, in the book's most uncomfortable ssage (for me at least), Mary Roberts hoes Alexander Pope in the *Essay on lan* by arguing that any change in ap- inted ranks will cause the exquisitely lanced apparatus of nature to tumble:

this splendid superstructure, nothing can added; neither can any thing be taken om it, without producing a chasm in cre- ion, which, however imperceptible to us, ould materially affect the general har- ony of nature. All things were made by m, and without him cannot any thing sub- st; besides, it seems as if he designed to ach us by the admirable arrangement of s creatures, that the different gradations in ciety are designed by his providence, and ppointed for our good.

These overtly sexist and politically con- rvative themes lie exposed at the surface f *The Conchologist's Companion*. But I as struck even more by the pervasive deep sexism" of Roberts's obedience to hat her society viewed (and we, in large nd unfortunate measure, continue to re- ard) as contrasting ideals of the abstract nd eternal masculine and feminine—the urest guide, I believe, to a true under- tanding of *The Conchologist's Compan- on,* and other works of this once influen- tial genre. I suspect that we can best grasp this vital, but largely covert, theme by returning to one of the most important essays in English letters—a document that many of us read (at least in excerpt) in Philosophy I, but have probably never thought about since: Edmund Burke's *Philosophical Enquiry into the Origin of Our Ideas of the Sublime and Beautiful,* first published in 1757.[1]

Burke argues that our aesthetic senses are moved by two separate configurations, which he calls the sublime and the beautiful. These are truly distinct, for one is not the negation or the reciprocal of the other. The sublime (which Burke also calls the "great") is based on our instinct for self-preservation and founded in terror. Among its themes lie vastness, darkness, verticality, massiveness, roughness, infinity, solidity, and mystery. The beautiful, on the other hand, is rooted in pleasure and linked to our instinct for generation (necessary for the preservation of our race, but not so elemental as self-preservation and the sublime). The themes of beauty include smallness, smoothness, variety in shape but only by rounded rather than angular transitions, delicacy, transparency, lack of ambiguity, weakness, and bright colors.

Burke does not dwell on the correlations of these themes with conventionally sexist views of the masculine (sublime) and feminine (beautiful), but this contrast sets the basis of "deep sexism." Burke argues, for example, that women instinctively recognize the necessary link between beauty and weakness:

> Women are very sensible of this; for which reason, they learn to lisp, to totter in their walk, to counterfeit weakness, and even sickness. In all they are guided by nature.

He also attributes the supposed grandness of male thought, and the timidity of

---

People often ask how or why I keep turning out these nonthly essays after nearly twenty years without a rest. he answer is so simple: Burke's essay is one of the reatest documents ever written in our language—for ll that I find repulsive therein (amidst other insights nat are truly wonderful). My volume of Burke has al- ays stood accessible on my bookshelf—as part of vol- me 24 in my set of Harvard Classics. My grandfather ought this set in the 1920s, when he decided that he ad to provide for himself and his children an opportu- ity for the education that he had never received. I oubt that he ever consulted more than a volume or two. My mother read and reread the volume on Aesop, Grimm, and Anderson during her childhood. I shot ar- ows at the set during my youth—and my volume 24 is ransfixed with nine holes marking my successes. I al- ays liked this particular volume because the spine ays: "On the sublime French revolution." I never vould have so characterized this episode in history, so the title always puzzled me. I don't know when I ever thought of actually opening the book, but I do remember my delight in discovering that the title mixed two separate works—Burke's essay on the sublime and his reflections on the revolution! These generational and ontogenetic continuities give meaning and structure to our lives. Then I shot arrows; now I want to read. I could have pulled this book off the shelf and read Burke's essay anytime—but I never did and, to be honest, I doubt that I ever would have done so amidst all the crazy and maniacal crowded business of our lives. My decision to write this essay on Victorian natural history brought me to Burke, and I had the wonderful privilege of reading this great and influential document for pleasure, and with some maturity of judgment, rather than in the rush of a course and for a grade at too young an age. For this privilege, I am most profoundly grateful. If I didn't write these monthly essays, Burke would probably have stayed on my shelf until the day I died.

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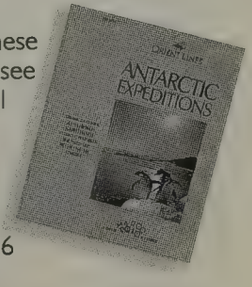
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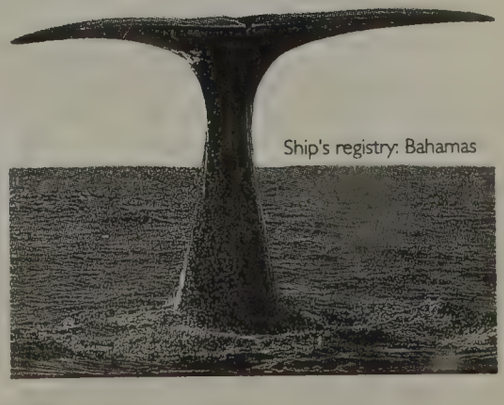
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female mentality, to this distinction:

> The sublime...always dwells on great objects, and terrible; [beauty] on small ones, and pleasing.... The beauty of women is considerably owing to their weakness or delicacy, and is even enhanced by their timidity, a quality of mind analogous to it.

I submit that we cannot grasp the essence of Robert's book, and the genre she represents, until we assimilate this classic distinction of the sublime and the beautiful. We must, above all, recognize that Roberts and her colleagues of like gender accepted this scheme and sought to be completely beautiful and not at all sublime—that is, essentially feminine by their light. (I also urge readers to acknowledge this distinction as both productive and supportive of the worst aspects of sexism—and to remember that liberation presupposes knowledge of the causes of oppression.)

Burke's criteria of beauty supply a key that opens *The Conchologist's Companion* to our understanding (rather than our ridicule based largely on puzzlement). The conceptual themes are all present: conventionality, timidity, boundedness, lack of surprise, rounded transitions. Even the physical appearances proclaim beauty rather than sublimity. These books by women tended to be small in size—printed at dimensions that publishers call duodecimo or small octavo, rather than the large octavo or quarto favored for books by male authors. Type sizes are generally small, and the engraved illustrations particularly delicate. The prose itself proclaims saccharine sentimentality, rather than raw power—particularly in the dum-de-dum of doggerel verses:

> Oh! Who that has an eye to see,—
> A heart to feel,—a tongue to bless,
> Can ever undelighted be
> By Nature's magic loveliness!

The choice of subject matter—small and humble mollusks—matches the attributes of a female writer, as Roberts mentions again and again:

> In the prouder forms of animated being, in the towering cedar, or the turret-bearing elephant, nature appears to act in a manner analogous to the grandeur of her designs; whereas these feeble creatures are often passed by, as undeserving the attention of the naturalist; and yet what tokens of beneficence and power, what exquisite perfection is discoverable!

Even the words of praise, used by men in their favorable reviews of women's work, invoked the standards of circumscribed beauty, rather than awesome sublimity. *The Athenaeum* (journal of the intellectual men's club that included Darwin and Huxley as members), praised Mary Roberts's second book on conchology as "a useful and entertaining volume" (issue of November 22, 1851, page 1124).

I was going to end this essay here, with some words of exculpation for Ms. Roberts, acknowledging her utter submission to conventional expectations, but refusing to judge her too harshly—for the urge to create can be so overpowering, and the pain of self-imposed silence so overwhelming, that we sometimes kowtow to the most iniquitous of limitations. (I dare not, as a white man, criticize Stepin Fetchit or Mantan Moreland for playing the only, if degrading, roles that Hollywood then allowed black actors. And I will not castigate any woman who needed to write, but could only be published by adhering to standards of Burkean beauty.)

But nothing in our complex world ever ends so cleanly. As I reread and considered, I began to see more in Ms. Roberts. I began to pick up an undertone of rebellion—muted to be sure, but unmistakably present. I began to realize that Mary Roberts had not totally internalized the norms imposed upon her, and that some flicker of feminine anger smoldered on the pages of her small and beautiful text.

One passage particularly caught my attention. Ms. Roberts often cites the conventional theme that nature will always hide secrets from human probing, and that we should not be too arrogant in our claims for understanding. She usually takes the standard line of attributing this prevailing mystery to masculine power—that is, to God's omniscience as creator of all nature, versus our mental midgetry by comparison. (She writes, for example: "In many instances we are unable to comprehend the intentions of the Deity with regard to the construction of his creatures.") But in one striking passage, she identifies the cause of obstruction as *feminine* nature—and she explicitly contrasts the necessary victory of this female power with the conventional image (used explicitly by Bacon and later writers) of science as male and active, seizing (almost raping) knowledge from passive, feminine nature:

> It seems as if maternal nature delighted to baffle the wisdom of her sons; and to say to the proud assertors of the sufficiency of human reason for comprehending the mysteries of creation and of Providence, "Thus far can you go, and no further"; even in the formation of a shell, or its insignificant in-

bitant, your arrogant pretensions are com-
etely humbled.

I knew that I had to probe further into
ary Roberts's hidden motives and feel-
gs. So I located her paleontological book
e Progress of Creation (1846 edition) in
e stacks of Widener Library (actually
t in the stacks, but further into purgatory
the book depository for rarely used vol-
nes and requiring a two-day wait for de-
very—another sign of invisibility for this
nre).

I was struck by an immense difference
style within a basic similarity of drearily
nservative content. *The Conchologist's*
mpanion may have made me sad for its
wing to limitations of a genre, but *The*
rogress of Creation made me mad for its
norant pugnaciousness in clinging to
early disproved religious formulations.
her geological book, Mary Roberts
kes a hard creationist line in insisting
on biblical literalism—with creation in
x days of twenty-four hours and a total
ge of only a few thousand years for the
rth. She states in no uncertain terms:

roughout this volume, I have ever kept in
ew, that the heavens, and earth were fin-
hed, and all the host of them in six days;
nd that no theory, however plausible, can
e admitted in opposition to the Divine
ecord.

She uses the writings of catastrophist
eologists to assert the reality of Noah's
ood and to argue that this deluge created
he entire geological record in one grand
ulp. But her argument is either ignorant
r disingenuous. By 1846, all serious cata-
rophists, including all the men falsely
uoted by Mary Roberts, knew that any
ood within human history could only
epresent the latest catastrophe in a long
eries of earlier crises stretching through-
ut an immensity of geological time.

Yet Mary Roberts wades in, dukes held
igh and swinging at all the greatest male
cientists of Europe. She thinks that
nastodons are carnivorous and lambastes
Georges Cuvier, the Newton of natural
istory, for his (evidently correct) belief
nat these elephants ate plants: "The car-
ivorous elephant, or Mastodon of the
Ohio, is one of the most remarkable. Cu-
ier describes this animal as herbivorous,
ut surely without reason." This is ab-
olute nonsense from Ms. Roberts's pen—
ut it is sublime nonsense.

What was Mary Roberts really thinking
when she wrote *The Conchologist's Com-*
anion by the rules of sweet, delicate, in-
offensive prose—when we know that she
could also write in pugnacious sublimity? Were her personal views on obedience and natural harmony as conventional as those she presented? Did she accept the limitations placed upon women, or did she seethe inside yet keep her own counsel? I doubt that the records exist to answer such questions—for a conventional history told largely by males did succeed in rendering her nearly invisible.

I wonder. What really went on behind the mask of acceptance and convention respected by most women writers on natural history? Perhaps we should invoke one of the great women of strength from our literature—Little Buttercup of Gilbert and Sullivan's *H.M.S. Pinafore*. She tries to tell the captain that "things are seldom what they seem"—perhaps also that women often hide the pain and anger of ages under a soft surface of acceptance:

Though to catch my drift he's striving,
I'll dissemble—I'll dissemble;
When he sees at what I'm driving,
Let him tremble—let him tremble!

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.



"The sea calls to us, mesmerizing in the rhythms of its quiet swells. As surely as the tides rise and fall, we will come back to her."



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Slaughter Sink, Missouri

by Robert H. Mohlenbrock

The Missouri Ozarks consist largely of porous limestone and dolomite overlain by stronger rock, such as sandstone. In many places beneath the surface, water has dissolved the limestone or dolomite, creating caves and passages, such as Meramec Caverns and Onondaga Cave. When a hollow collapses, the overlying sandstone falls into it, leaving a basin known as a sink. Hundreds of sinks of various sizes are scattered throughout the Ozarks. A spectacular one is Slaughter Sink, which lies in Mark Twain National Forest, along the northern edge of the Ozark Mountains.

Slaughter Sink is nearly one-quarter mile wide and 175 feet deep; its steep sides are dolomite. Overlooking the western rim is a sandstone promontory flanked by a dolomite pinnacle. Known as Chimney Rock, the thirty-foot-tall pinnacle is perched on a fifteen-foot pedestal.

The floor of Slaughter Sink is nearly flat, except for a secondary, small sink at its northern end. When the basin floods



Slaughter Sink, viewed from the south, above, floods during a spring thaw. A yellow lady's-slipper orchid, left, grows at the base of the sink wall.

Don Kurz

after heavy rains, the water drains through this small sink, then meanders for nearly a mile in a subterranean stream until it emerges as bubbling Boiling Springs near the Gasconade River. The spring also delivers water from other sinks in the vicinity, pouring 42 million gallons into the river each day.

The hilly terrain that surrounds Slaughter Sink supports an upland forest of black, red, post, and blackjack oaks and red cedar. Flowering dogwood and redbud are common smaller species, providing colorful blossoms in early May. Sandstone boulders are strewn across the forest floor.

On a dry, west-facing slope above the sink is a two-acre dolomite glade, an open area sprinkled with limestone and chert pebbles. The only woody species that survive here are some red cedars, an ironwood, and a few shrubby, white-flowered ninebarks, members of the rose family. The glade is dominated instead by prairie grasses (big and little bluestem, side-oats grama, and switch grass) and prairie wildflowers (blazing-star, wild petunia, Missouri coneflower, rosinweed, false boneset, horsetail milkweed, and purple prairie clover).

A narrow strip of woods with red maple, black oak, blackjack oak, Carolina buckthorn, and red cedar grows around the lip of Slaughter Sink, a relatively dry zone because of exposure to the afternoon sun. In early March, before the leaves come out, white flowers with five narrow petals adorn the branches of small serviceberry trees. Summer wildflowers include Indian-physic, bee balm, yellow lousewort, and St.-Andrew's-cross. Broomrape, a four-

A long spike rises from the flower of the dragon plant.
Don Kurz



inch-tall plant that produces a single, inch-long, tubular white flower, is unusual among flowering species because it lacks leaves and chlorophyll. It obtains nutrients by attaching itself with rootlike threads to the roots of various other plants.

The sink's steep dolomite walls sustain a variety of plants that lodge in the crevices of the rock. Most are species restricted to dolomite or limestone. They include a number of ferns—two kinds of purple cliffbrakes, dwarf lip fern, black spleenwort, and bulblet bladder fern. Nea the base of the sink's walls, a terrace ha built up from material washed down th slope. This terrace supports a forest of re and chestnut oaks, basswood, suga maple, box elder, and black walnut. Spice bush and bladdernut are the dominan shrubs, while maidenhair fern, jack-in the-pulpit, and yellow lady's-slipper or chid are among the wildflowers.

Most of the forty-acre floor of the sin is covered by vines and wildflowers, wit scattered silver maples, black willows, an persimmons. The vines include summe grape, greenbrier, raccoon grape, moon seed, trumpet creeper, and poison ivy while the principal wildflowers are spotte spurge, prickly sida, and false nettle. Th most striking wildflower is green-dragon which has an eight-inch-tall spike protrud ing from its compact flower.

Slaughter Sink is home to the extremel rare Salem cave crayfish, known onl from a few caverns in the Ozarks. I spends most of its life in subterranea areas, and as a result of its adaptation, it i white and blind. Crayfish may be found i nearly every freshwater habitat in Nort America, from cold northern lakes t warm southern swamps, from water-satu rated fields to fast-flowing streams. Bu owing to its secretive life style, the Salem cave crayfish found in Slaughter Sink ha seldom been observed.

Robert H. Mohlenbrock, professor emeri tus of plant biology at Southern Illinoi University, Carbondale, explores the bio logical and geological highlights of th 156 U. S. national forests.





Joe LeMonnie

Slaughter Sink

For visitor information write:
Forest Supervisor
Mark Twain National Forest
401 Fairgrounds Road
Rolla, Missouri 65401
(314) 364-4621

Why All Americans Should Support a Moratorium on Immigration

FACT: More alien workers entered the U.S. labor market in 1992 than jobs were created, according to Immigration Service and Department of Labor statistics. America's disadvantaged workers suffer disproportionately from the steady influx of low-skilled, low-wage labor. The Zoe Baird incident was only the tip of the iceberg.

FACT: The Census Bureau now projects that there will be 383 million Americans in 2050, largely because of what *The Washington Post* describes as "massive immigration." That's 50 percent more Americans than there are today, and 83 million more than the Census Bureau projected just four years ago.

FACT: Thousands of illegal immigrants enter the country every day—2 million to 3 million a year. Even Clinton's job stimulus package can't employ all new immigrants who are arriving. Fake documents are easily obtained, providing access to benefits meant for legal residents.

Our national political leadership is apparently unaware that a majority of Americans of all ethnic backgrounds favor reduced immigration (Roper Poll, May 1992; Latino National Political Survey, December 1992). In fact, immigration policymakers seem more concerned with pleasing the special interests than doing the will of the people they are elected to serve.

The Federation for American Immigration Reform (FAIR) wants to change that.

FAIR is working for a moratorium on immigration until the United States can:

- substantially eliminate illegal immigration;
- establish a secure work authorization system;
- revise immigration law to reduce overall numbers; and
- complete a comprehensive analysis of the long-term demographic, environmental, cultural and economic effects of future immigration and population growth.

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Washington, D.C. 20009 NH 693

Phony Medium

Here's some free advice

by Roger L. Welsch

As I understand it, a miracle of modern communication took place on March 10, 1876, when Alexander Graham Bell shouted into his telephone prototype, "Mr. Watson—Come here—I want to see you." Watson, Bell's assistant, heard the appeal through his end of the two-party telephone line and came running.

The miracle, of course, was not that electrons were excited, that sounds were "encoded" and "decoded," that the laws of physics functioned yet again as they always had and always would. The miracle was that someone actually answered the telephone. The odds of that happening have been on the downswing ever since.

Okay, the telephone may have been a good idea at one time, but so were smoke signals. By now just about everyone realizes that telephones no longer work. Certainly, of the last 376 telephone encounters I have had, each and every one has followed the same debilitating pattern. I come in from the shop or town or San Francisco, touch "rewind," and listen to the messages on my answering machine, most of which are something like "Hello, Mr. Welsch. This is Denny Drimble from Jolly Pup Manufacturing, and I would like to talk with you as soon as possible. I have something really important to tell you. Please call me at home—nine one three, five five five, two six oh six—or the office—nine one three, five five five, five five four five—as soon as possible."



Call Forwarding of the Wild

Hmmm. Great. If it's so important, why didn't Mr. Drimble just tell me what he has to say? Probably because he wants me to pay my share of the phone tab. Well, okay, if it's important. I try his home phone, 913 555-2606, first. Busy. Well, maybe it's his wife or kids. He may be at work. I'll try the office, 913 555-5545. Ah! It rings. Fifth ring, funny click: "Good morning. This is Jolly Pup Manufacturing. All our lines are busy at the moment. Please do not hang up. One of our receptionists will be with you as soon as possible."

Ten minutes later I am still sitting there, my telephone meter running, listening to torture music and commercials for Jolly Pup Manufacturing's canine worming pills. Finally, a human voice: "Jolly Pup Manufacturing. May I direct your call?"

"I'm calling for Denny Drimble."

"I am sorry, Mr. Drimble will not be in today."

Great. The balance sheet now reads that three long-distance calls have been placed, fifteen minutes and five dollars have been blown, but not one minibit of information has been transmitted. Alexander Graham Bell did better in the first three words of the call he made to Watson.

Okay, maybe Drimble is at home. Back to 913 555-2606. Throughout the rest of the day I call several times, getting busy signals or no answer. That evening, on the seventeenth call, I get a ring and, at last, an answer. "This is Denny Drimble [Oh no. An answering machine!] I can't come to the phone right now, but if, at the beep, you leave your name and number, I'll get back to you as soon as possible. BEEP."

"Uh, yeah. This is Roger Welsch, returning your call, but unable to leave any information, since you didn't leave me any idea of what it is that you want. Have a nice day. What goes around, comes around. All's fair." Dozens of calls, all day and six bucks wasted, no information exchanged.

A couple of days later, I find another Drimble message on my machine: "This is Denny." Great. Now we're on a first-name basis, even though we've never so much as exchanged two words. "You can try me again at home this evening or tomorrow at the office." He repeats his numbers. He does not leave any information about why he called me in the first place. I try to reach him, again without success.

Unfortunately—maybe—Denny left the new message on my machine Tuesday morning, while I was in Houston. When I call him Friday, *he* is in Houston.

Almost six weeks go by before Denny finally gains confidence and opens up to my answering machine. Meanwhile, combined, we have spent nearly an hour on the telephone with this matter and more than twenty-five dollars. Turns out he wants to know if I'm the Roger Wells who pitched

or the semipro Rolla, Missouri, Tiger Cats in 1949. I leave a message on his machine that I was thirteen years old in 1949 and I spell "Wells" kind of funny—like W-e-l-s-c-h. "By the way," I ask his machine. "Why didn't you just drop me a postcard last month when we started this whole thing?"

His answer, which he leaves on my machine while I am taking a shower, is, "I didn't write, you idiot, because I was working on a high school reunion and *I was in a hurry.*"

By now you know that I'm not the sort to criticize society, science, culture, nature, or my wife without offering up some handy advice. Here it is.

On your telephone table tomorrow, you're going to find two piles. The first is your mail. You will be able to take care of all fifteen items in that pile in a little more than an hour for a total cost of about four dollars. The other pile consists of fifteen telephone messages. They will take more than four hours stretched out over a full week, will cost nearly fifty dollars, and will raise your blood pressure to a figure remarkably close to the diameter of Pluto in kilometers. (You will *never* reach Mrs. Vera Klottsmuth, or something like that, at four oh nine, two one one, something something six something, who apparently wanted to warn you about a recall of your gas brazier, brass brassiere, or glass razor because of recurrent explosions. Or maybe AC-current corrosions.)

I have found that if you answer your mail and throw away your telephone messages, there are no consequences. No one who matters uses the telephone. No information worth the fuss comes to you by telephone. Can you imagine Ed McMahon calling on the telephone to tell you that you may have already won twelve million dollars? Take it from me, Ed will write.

Folklorist Roger L. Welsch lives on a tree farm in Dannebrog, Nebraska.





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A small tortoiseshell, a migratory butterfly, basks on a yellow daisy.
Geoff Du Feu; Planet Earth Pictures



Butterfly Mass Transit

Undaunted by deserts, mountains, or cities, winged legions cross continents

by Torben Larsen



"Buddha banded peacock approaching the garage," shouted our lookout. His voice sounded faint; he was posted as far away as possible to give us maximum advance notice, and the Buddha banded peacock was a real prize. The year was 1954; I was ten years old, at boarding school in the Nilgiri Hills in southern India, and the annual butterfly migration had just begun. It lasted for more than a month, a continuous stream of more than twenty species, all flying relentlessly in the same direction. They maintained their chosen direction so precisely that our lookouts were able to alert us to anything special. And we saw many special kinds of butterflies, since most of the migrants did not breed at 6,000 feet, the elevation of our school. Where the butterflies came from, and where they went, were mysteries to us.

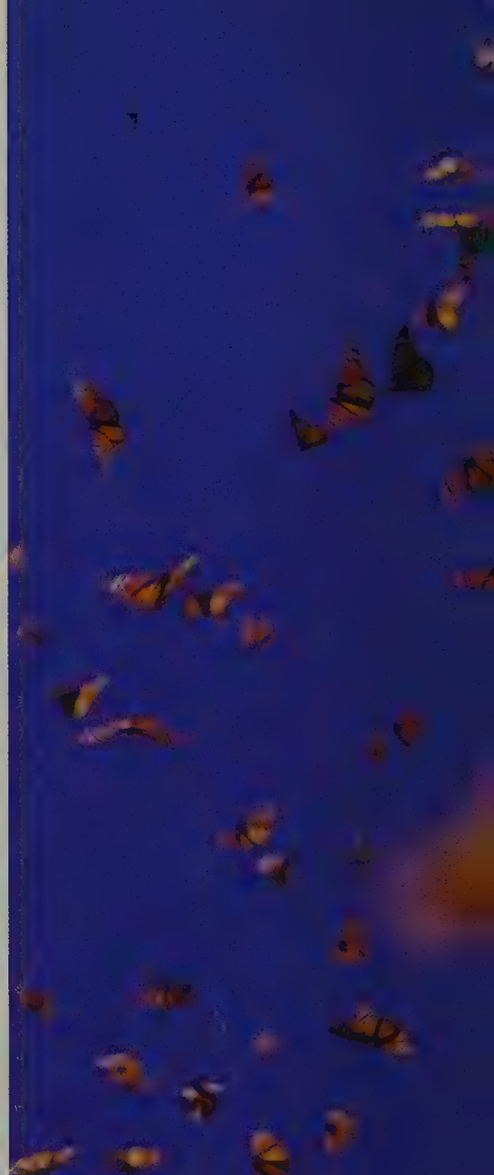
With varying intensity, this migration was repeated every year, and I left the Nilgiris at the age of fourteen thinking that this was a very ordinary occurrence. In fact, southern India and Sri Lanka are along the pathways of an exceptional migration. Many years later, just before his death, I told C. B. Williams—a pioneer in the study of butterfly migration—about my experiences. He urged me to publish them. Despite my protests that childhood reminiscences of this nature had no place in the scientific literature, he was insistent, and I began to gather data from the margins of my old butterfly books and from the many letters that I had been forced to write to my parents. I even tracked down my former headmaster, who still had a collection I made at the time, with many specimens marked "migrant." I eventually produced a decent, although tentative, paper. Only thirty-two years later did I return to the Nilgiris to shed more light on the matter.

How does one recognize a butterfly migration? On the scale at which it happened in the Nilgiris, no one could be in doubt. Millions of butterflies cascaded down our mountainside, across the valley, and up the other side, all flying with determination in the same direction, sometimes even vertically up cliffs. No obstacle will stop migrants. Once I stayed on the ninth floor of

A mixed group of caper white and African emigrant butterflies, below, stops to feed at a cow pat in Botswana. Right: To reach the communal Mexican tree roosts in which they overwinter, millions of monarch butterflies travel up to 2,500 miles from eastern North America.

Both photographs by Torben Larsen





a hotel in Nairobi, Kenya, during a migration. All the butterflies flew over the roof of the hotel, none making the slight detour that would have allowed them to bypass the building. Even when a migrating butterfly is trapped on a porch, it appears to be trying to batter down the house, and will persist in its chosen course rather than retreat a few yards or deviate from it. At the risk of being anthropomorphic, I find that migrating butterflies really do seem to have a "gleam in their eyes."

Most butterfly migrations are low-key affairs that go unnoticed. However, an alert and patient observer can recognize even "thin" migrations. I often spot what I take to be a migrant and then keep watching. Sure enough, after a minute or two, or five, I see another, and yet another butterfly. They are out of sight of one another, but all fly in exactly the same direction.

From 1970 to 1975, I lived in Lebanon and wrote a book on the butterflies there. I began to realize that migration of some sort was very important to the butterfly fauna as a whole. Of the 136 butterfly species in Lebanon, at least 26 (or 19 percent) migrate to some extent, although most do so only in low densities. Several major migration patterns could be detected in Lebanon, however, and these patterns also hold true for other parts of the world.

One migratory group consists of species that breed high in the mountains of Lebanon and then migrate to hibernate as adults lower down the mountains and on the coast, where winter is milder and hiding places easier to find. Their uphill return flight is one of the first heralds of spring in this part of the world. Art Shapiro, a professor of biology at the University of California at Davis, tells me that very similar migrations of related species are seen in California. Although the distances traveled by these altitudinal migrants are short, the ecological changes are profound.

A second group, of which the red admiral is typical, migrates due north in spring from the Mediterranean, occasionally reaching the Arctic Circle and breeding there. By autumn, the red admiral may be common all over northern Europe, but those that do not eventually set off south will perish. No red admiral life stage—egg, larva, pupa, or adult—can survive a northern European winter. At the other end of their range, red admirals occasionally breed in winter as far south as the Nile Delta, where summers are much too hot for their survival.

The third major group, of which the African monarch is characteristic, consists of tropical species that in good years push their frontiers northward. They sometimes establish breeding populations for several years before a severe Mediterranean winter kills them. During the 1980s, the African monarch established many breeding colonies in Spain and elsewhere, strongly extending its usual breeding range. Many of my colleagues believe they are now permanent residents, and some even think that their range extension is the result of global warming. Although one Danish humorist has said that "predictions are always dangerous, especially about the future," I'm still ready to wager that a series of severe winters will restore the *status quo ante*.

The final group consists of the eternal nomads typified by the painted lady. In

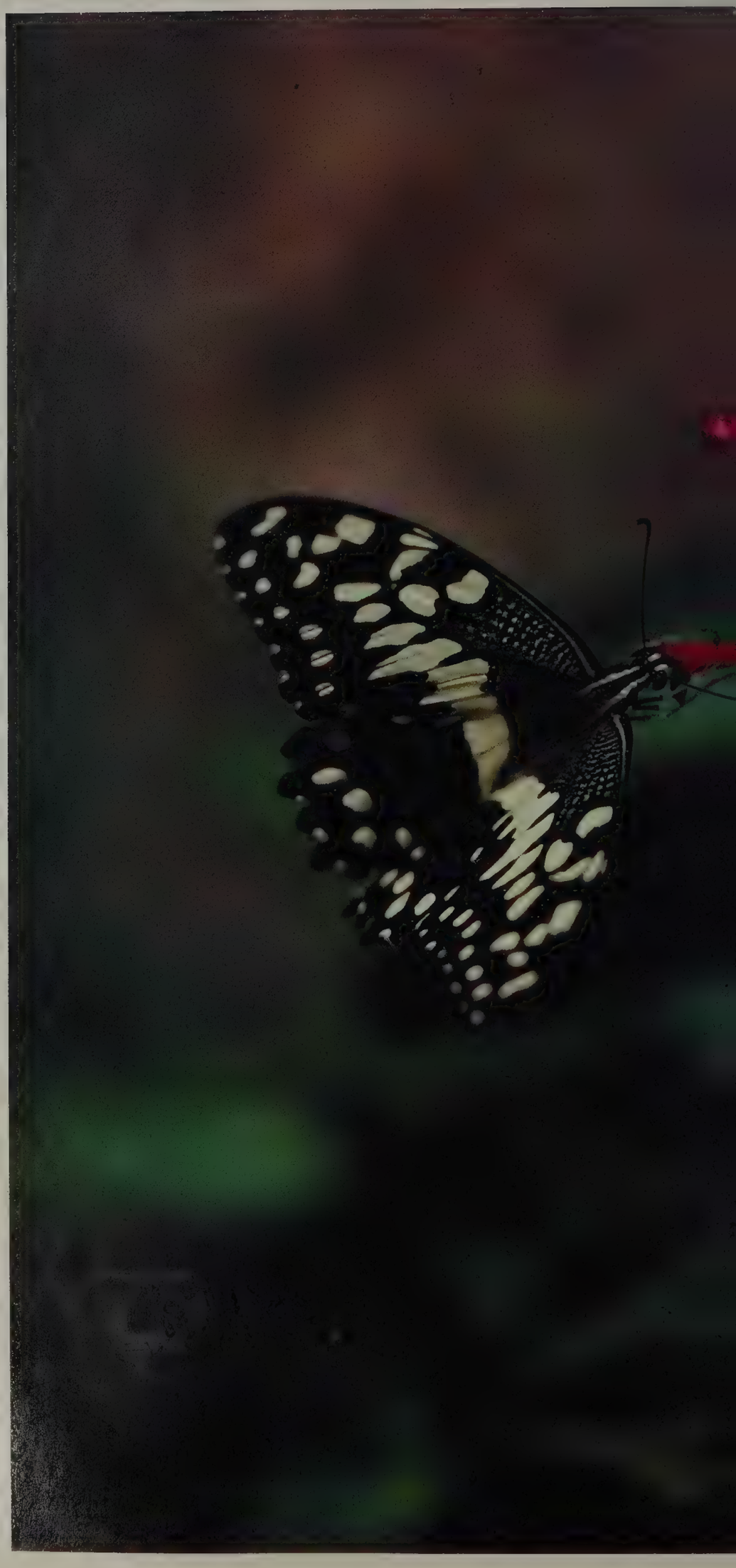


early November 1974, tens of millions of these butterflies hatched in and around Cairo only to leave immediately. I spent much of the year's end looking for them either as larvae or adults, but I found only a handful. In 1947, George Popov, a specialist in grasshoppers of the dry zone, saw countless painted lady larvae advancing across the Saudi Arabian desert with young hoppers of the desert locust, gorging and leaving no trace of the lush green spring vegetation that had sprouted after the year's unusually good rains. Some migrating painted lady females had found this bounty and laid their eggs. Their offspring would have to migrate soon after hatching, as the desert would again be parched. And from this desert vantage, any direction would have served the butterflies well. North would lead them to spring on the Anatolian plateau; south to lush pastures of the Yemeni mountains; east to the Zagros Mountains of Iran, where conditions would be perfect for breeding; and west, to the Nile Valley. Since the painted lady does not hibernate or estivate (lie dormant in summer), probably very few places exist where it can be certain to survive year round. Because of its nomadic life style, the painted lady is the world's most cosmopolitan butterfly. Except for South America and some rain forest zones, it is found practically everywhere. Mass migrations of painted ladies are also common in the southern United States and Mexico.

More than a hundred years ago, S. B. J. Skertchly recorded the beginning of a migration of painted ladies at Suakin on the Sudanese Red Sea coast:

> At the foot of the high country is a stretch of wiry grass, beyond which lies the rainless desert as far as the sea. From my camel, I noticed that the whole mass of grass seemed violently agitated, although there was no wind. On dismounting, I found that the motion was caused by the contortions of pupae of *V. cardui* [the painted lady], which were so numerous that almost every blade of grass seemed to bear one. The effect of these wrigglings was most peculiar—as if each grass stem was shaken separately, as indeed was the case, instead of bending before the breeze.... Presently the pupae began to burst and the red fluid that escaped sprinkled the ground like a rain of blood. Myriads of butterflies, limp and helpless, sprinkled the ground. Presently the sun shone forth, and the insects began to dry their wings, and about half an hour after birth of the first, the whole swarm rose as a dense cloud and flew away eastwards towards the sea. I do not know how long the

Don Fawcett



swarm was, but it was certainly more than a mile, and its breadth exceeded a quarter of a mile.

After my work in Lebanon, I began to research the butterflies of Arabia. I still remember the look of disbelief with which acquaintances usually greeted this piece of information: "But surely there are no butterflies in Arabia!" But there are—150 species in all—and, as is the case throughout the arid zones of the world, migration is an essential part of their life history. The driest parts of Arabia support about forty butterfly species, of which twenty-three (nearly 60 percent) are known to migrate. I saw my first real migration outbreak near Rostaq in northern Oman in May 1981. In a number of small wadis—valleys gouged out by occasional heavy desert showers—caper trees grew in profusion. But while they should have been in prime spring condition, these trees bore no leaves. On closer inspection, I saw that they had all been defoliated by pupae of the caper white butterfly, a mass migrant. The word *defoliated* is meant quite literally. Not a leaf was left. Thousands of pupae clung to every tree; I plucked off 2,500 from a very small one. As the temperature climbed toward 113° F, I cruised up and down the wadis trying to estimate the number of pupae in them. I concluded that, conservatively, at least ten million butterflies were waiting to hatch in a place where no food would be available when they emerged. I was able to investigate only a few of the smaller wadis; I dared not guess how many pupae might have been harbored in larger, neighboring ones.

Soaring temperatures and the glare of the white granite cliffs had made difficult an otherwise satisfying day (and, geography notwithstanding, led to a frightening attack of snow blindness). I had, however, gathered several thousand pupae and loaded them into my Land Rover to take home so that upon their hatching I could determine their sex ratio (proportion of males to females) and the degree of parasitization, which may reach 50 to 80 percent in resident populations. Within a week, the pupae hatched. The sex ratio

A citrus swallowtail, left, feeds from a flowering plant in the acanthus family. This migrant usually lives up to its name by seeking out small, isolated orange or lemon trees on the edge of the Sahara or Kalahari deserts. Below: Very occasional migrants, common swordtails ingest dissolved salts from a damp patch of sand near the Luo River in Zaire.

K. and K. Ammann; Bruce Coleman, Inc.



was normal, but not a single pupa was parasitized. Probably mass breedings like this one, undertaken at irregular intervals, cannot be "tracked" by the parasites. In just a few days, northward migration duly started.

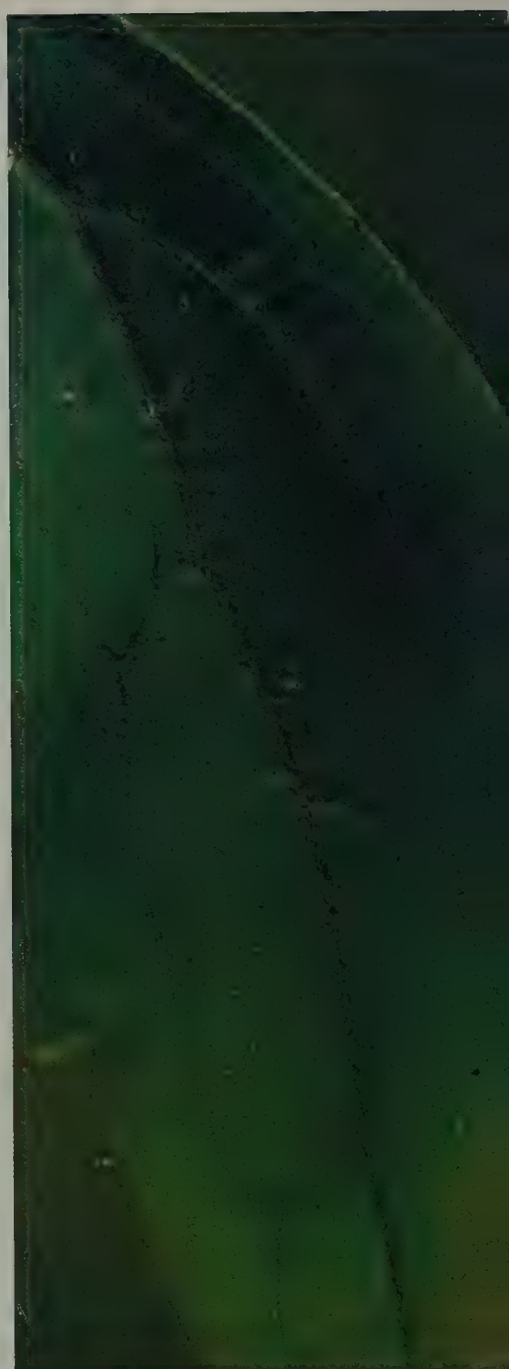
My experience in Oman is similar to that described by C. R. S. Pitman in northern Uganda in 1926:

> One can only describe as amazing the vast breeding-grounds encountered. I have never before seen such countless myriads of butterflies, and as far as the eye could see there was a shimmer of white just above the surface of the ground. The majority of the food shrubs…seemed practically leafless—larvae and chrysalises were everywhere.

After this migration descended on Nairobi, an isolated, three-foot-tall caper bush was found to contain 57,000 eggs and newly hatched larvae.

I also saw a migration of the caper white in Kenya in December 1975. In one day, more than four million passed in a "front" only about twelve miles wide. I was puzzled by the narrowness of the front. Study of a map suggested that the butterflies were being funneled between

Stephen Dalton; NHPA



The Buddha banded peacock, below, is a rare member of huge flocks of mixed migrants that annually cross southern India. Right: A small tortoiseshell, a species of butterfly found from northern Europe to the Himalayas, takes flight. In Lebanon and Turkey, small tortoiseshells are altitudinal migrants, flying from their mountain breeding grounds to overwinter at lower elevations.

Torben Larsen

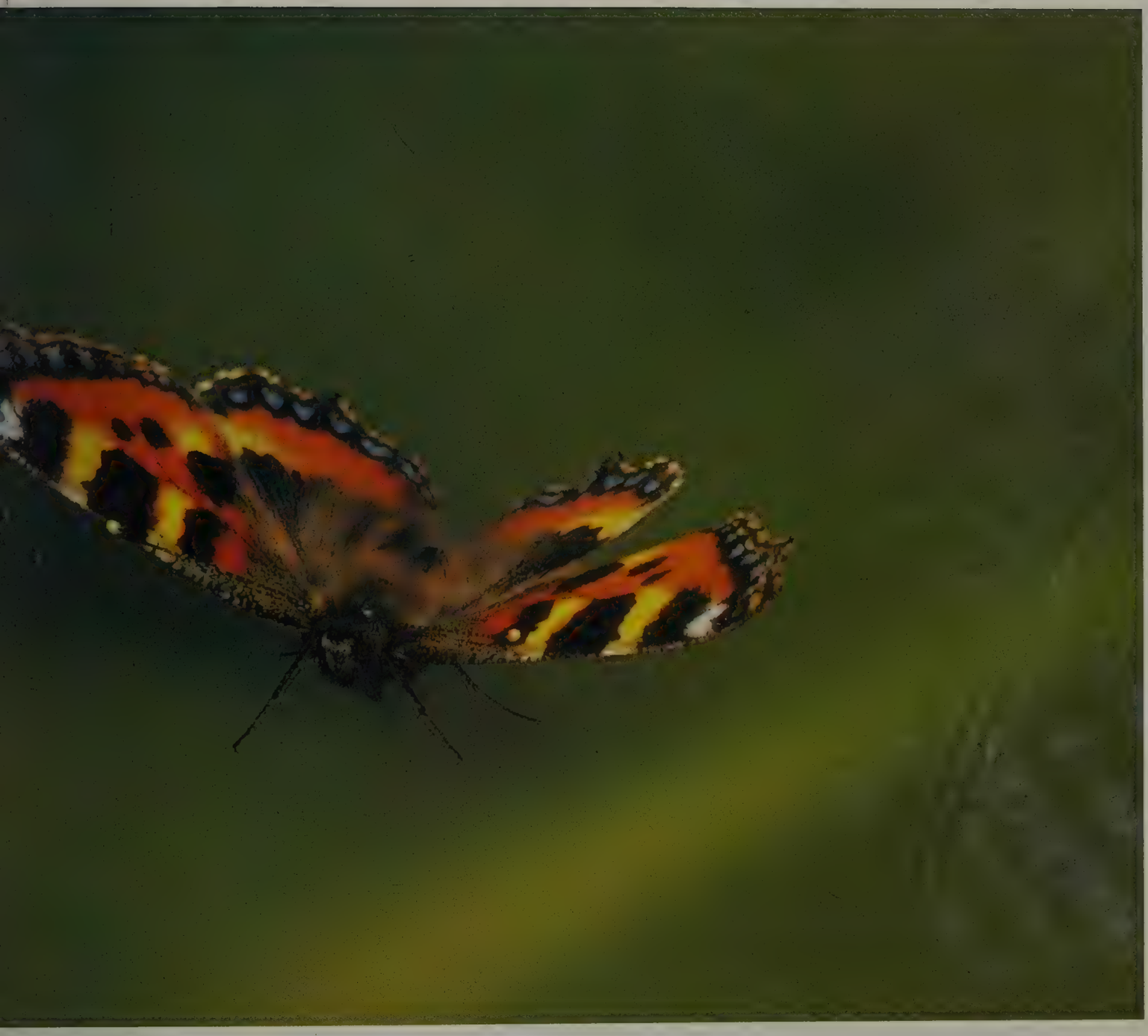


the Aberdare range and Mount Kenya, but migrating butterflies generally do not allow themselves to be influenced by geography once they have set off in a given direction. The next day, I made for the Aberdare range. I drove through a steady stream of migrating caper whites, and as I reached the plateau at almost 10,000 feet, clouds began to gather. I suddenly found myself in a rain of caper whites, which fell limply out of the sky by the thousands. As they reached the plateau and came into the shade of the clouds, their body temperatures dropped to the point where they could no longer fly. No funnel effect had deflected them; those flying over the Aberdare range and Mount Kenya were simply physiologically stopped in their tracks.

Migrating butterflies can travel long distances over water. In April 1988, I encountered a moderate migration of painted ladies in southern Portugal, flying north-northwest. I knew they must have come from Morocco: April is too early for them to breed in Portugal or anywhere else in Europe. I tracked their path on a map, and they seemed to be heading for Ireland. Responses to a letter I wrote to some of the Irish newspapers confirmed their destination. Painted ladies were generally scarce in Ireland, but many were being sighted at the time, particularly in the southwest. The total distance traveled was about 1,200 miles, including 600 miles nonstop over water. Very rarely do painted ladies reach Iceland, but that year a number arrived there at the appropriate time, having flown 2,100 miles from North Africa, perhaps resting in Ireland on the way.

A long-distance traveler well known in North America is the monarch butterfly. Every autumn, monarchs begin to fly south from eastern Canada and the United States to hibernate in a few huge roosts in the mountains of Mexico's Michoacan province, a flight of more than 2,400 miles in some cases. The largest of these roosts may contain more than sixty-five million individuals. After spending several months, flying and feeding only occasionally, they begin to fly back north in spring, laying eggs along the way, then dying. Few, if any, make the entire return journey, but their offspring recolonize the northeast every year. In many respects, this is like the first group of Lebanese migrants, moving from a breeding ground to hibernate under very different ecological conditions, although the distances covered by the monarchs are much greater. I visited the main Mexican roost at Rosario in December 1990. I had read most of what had been published on monarchs and had seen films about them, but standing alone among sixty-five million butterflies was one of the most breathtaking experiences of my life. Because the localized mountain roosts are vulnerable to human disturbance, conservation efforts are aimed at safeguarding the monarchs and the phenomenon of monarch migration.

In February 1991, my wife and I were conducting entomological research in the extreme southwest of the Kalahari in Botswana. We were lucky; January had brought abundant rains in what is essentially a desert. Plants were green and butterflies plentiful. Locals had not seen such lushness for fifteen years. The most numerous butterfly was the African emigrant, often attracted to mud puddles in large numbers. On the first of March, we



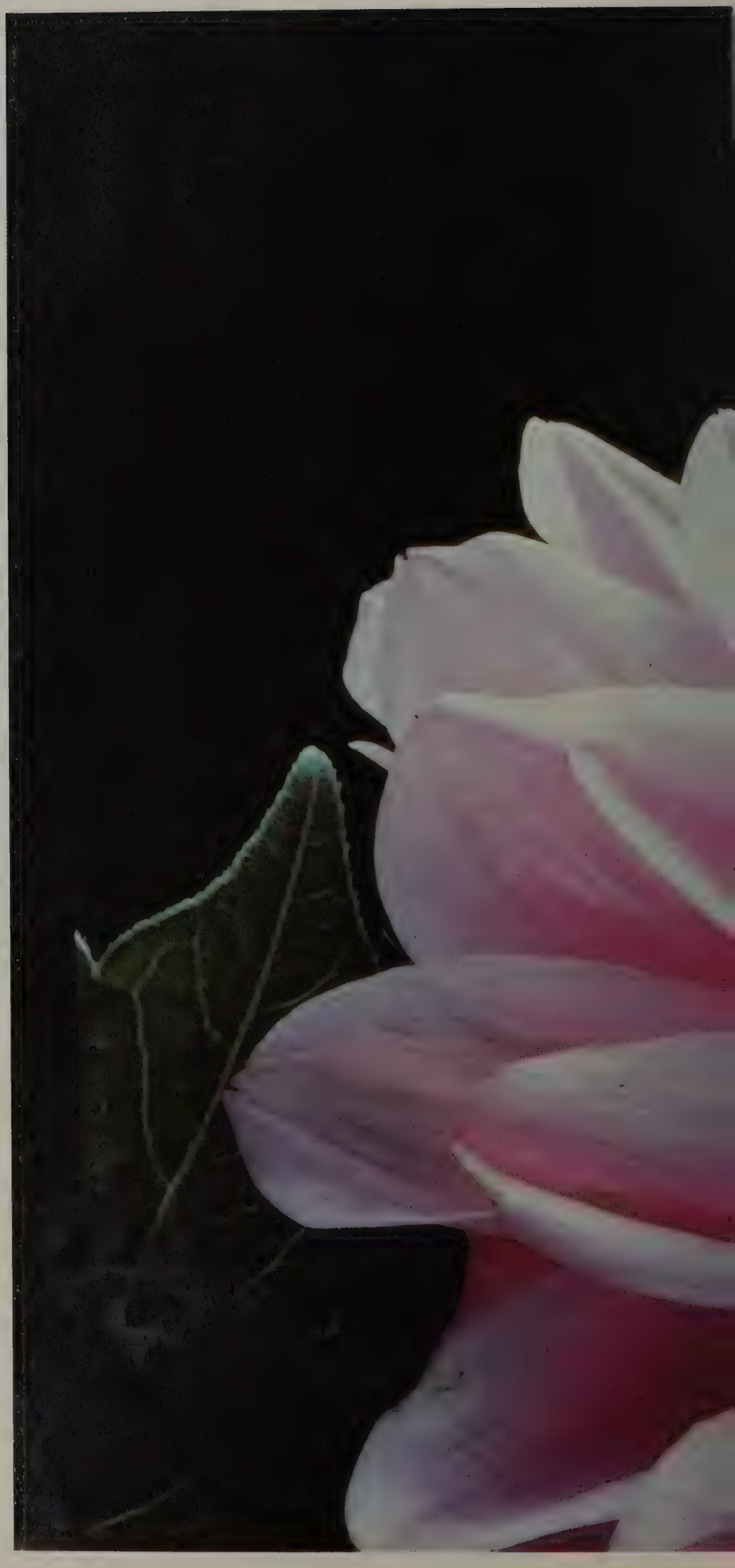
were delighted to see the start of a migration of this species. They passed for the most part at a rate of about ten per minute over a 330-foot front, but at times the density reached 400 per minute. The direction was always east-northeast, wholly independent of wind direction or angle of the sun. The females were of two main forms, one yellow and one white; we discovered that all the nonmigratory females of the parent generation were white, while all the migrant females were yellow. More subtle differences existed between nonmigrant and migrant males. Migrant males were not sexually active, but migrant females were often waylaid by old, well-worn, nonmigrant males.

During the next month and a half, we saw this migration in all parts of Botswana and received much additional evidence from elsewhere in southern Africa. When the time came to estimate the numbers involved, the total, based on deliberately modest assumptions, came to 1.5 billion butterflies, one of the largest butterfly migrations ever recorded. (A related butterfly, the Neotropical sulfur, is also known to migrate en masse.) Data from Zimbabwe indicate that African emigrants regularly migrate in the direction of Botswana in November and December, probably arriving in such small numbers that they are not usually recognized as migrants. A regular return migration may take place as well, but in normal years, breeding conditions in the Kalahari are poor, and the migration scant. With the unusual January rains, however, the butterflies appeared in such numbers that they sometimes blocked the vision of people driving cars; a pilot even complained that he had had trouble landing at a Kalahari airstrip.

While the scope of this migration was the largest I ever witnessed, the densest one I ever experienced was in southern India in my childhood. We were traveling by car toward Mysore when the sky was suddenly darkened by a huge migration of butterflies known as common crows, related to the monarchs. Driving became impossible; the windshield was soon smeared thick with dead butterflies, and the car radiator, gummed up with juicy corpses of freshly hatched common crows, boiled over.

No one has ever succeeded in following a migration from its outbreak point and along its entire path to its destination and then studying what happens at the stopping point (usually covering a large area). One really needs a helicopter for that. As the examples given show, butterfly migration involves several different phenomena. Most migration takes place in areas with great seasonal differences—summer and winter in the temperate zones, wet and dry

A North American monarch alights on a pink dahlia.
Jim Hays: Unicorn Stock Photos



seasons in the tropics. Migration is generally rare in the true rain forests with their equable and predictable climate. My research in the Nilgiri Hills in 1986 showed that the migrations there allowed butterflies to spread into most of India to take advantage of the advancing southwest monsoon, and the migrations in Kenya are always just before the two main rainy seasons. In Botswana, migrants arrive when rains are due (although these often fail), and the return is well after the rains peak. However, much migration seems to be basically opportunistic. In addition, some migrations consist almost exclusively of a single species, while others are mixed affairs of up to twenty species, all flying in the same direction, despite differences in size, strength, and flight pattern.

What triggers migration, what imprints flight direction, and what unerringly maintains it remain unknown. Over the years, I have become convinced that direction is maintained with the help of the earth's magnetic field, but I have never been able to test this hypothesis (some moths are now known to have electromagnetic sensors). The angle of the sun has been suggested as a guide for migrants, but in Kenya, India, and Botswana, migrations continue steadfastly with the sun directly overhead. Visual navigation through the use of successive, prominent landmarks has found favor with some researchers, but in the flat vastness of the Kalahari, no such landmarks exist.

Some butterflies can and do migrate in amazing numbers and for surprisingly long distances. Without migration, some species, like the cosmopolitan painted lady, might well be limited to a few areas where it could survive year round. I believe that, particularly in the dry tropics, migration is much more important for the population dynamics and species composition of butterflies than is often recognized. Migration, which allows some butterfly species access to far-flung but vital resources, is not a chance event, but a finely tuned evolutionary adaptation. As a natural phenomenon, it is always a delight to observe. □





In an Australian drama of some 60,000 years ago, a wolflike thylacine (bottom, right), finds its pursuit of a short-faced kangaroo cut short as a leopard-sized marsupial lion leaps from its vantage point and pounces onto the victim's back.

Paintings by Peter Schouten

The Case of the Missing Meat Eaters

Why are Australia's carnivores particularly coldblooded killers?

by Tim Flannery

During ice ages, when sea level is low, Australia, Tasmania, New Guinea, and their smaller neighbors coalesce into a single great island. Dubbed Meganesia by scientists, this landmass covers an area of almost 4 million square miles and is a single geological entity, carried across the Southern Hemisphere by plate tectonics. Meganesian plants and animals thus share



Adapted from *Australian Natural History*

a common biological heritage, and even when the sea carves their great island homeland into discrete pieces, the flora and fauna retain their affinities. In addition to an abundance of marsupial, or pouched, mammals and a dearth of placental mammals, one of Meganesia's most striking features is its extraordinary lack of large mammalian carnivores.

This unusual situation is perhaps best illustrated by going back some 60,000 years, before the arrival of humans in Australia. At that time, Meganesia was home to approximately sixty species of mammals that weighed more than twenty pounds. Of these, not more than three were meat eaters, and all are now extinct. Only two other warmblooded carnivores weighed more than ten pounds, and they still survive: the Tasmanian devil and the spotted-tailed quoll. Each of these species fills, or filled, a somewhat different ecological niche.

The Tasmanian devil, a scavenger and bone cruncher that takes whatever prey comes its way, is perhaps best described as a miniature marsupial hyena. Also a marsupial, the spotted-tailed quoll is weaselike or civetlike in both appearance and in its stealthy behavior. The now-extinct thylacine (which survived in Tasmania until 1936) was roughly the size and shape of a wolf and was Meganesia's only doglike marsupial carnivore. Also extinct, the marsupial lion, one of the few carnivores to have arisen from herbivorous ancestors, had large, slicing premolars. This led some nineteenth-century scientists to speculate that it was a vegetarian that fed mainly on melons. But the discovery of a well-preserved fossil paw revealed that it was equipped with a big hooded claw, and the marsupial lion is now believed to have been an adept predator. Despite its common name, it was closer in size to a leopard than a lion and may have been the marsupial equivalent of the medium-sized cats on other continents.

The marsupial giant rat kangaroo weighed a hefty ninety pounds and stood some four feet tall but had teeth similar to those of much smaller insectivores. This beast lived throughout eastern Australia—in woodland, grassy steppeland, and savanna—during the last ice age. Its ecology is enigmatic, however. It may well have been an omnivore, eating plants, scavenging carcasses, and opportunistically preying on bird eggs and small vertebrates. If such an interpretation of its diet and habits is correct, this primitive kangaroo may have filled a niche similar to that of some small bears.

In the entire Australasian region, therefore, the broad carnivore niches were filled by just one mammal species each—doglike, catlike, civetlike, scavenging, and, possibly, bearlike animals. In contrast, even today the United States (the lower forty-eight of which are roughly the size of Australia) is inhabited by three bear species, five kinds of dogs, six kinds of cats, six species of weasels and their relatives, as well as raccoons, ringtails, and coatis. And the region's abundance of carnivores pales when compared with its fauna during the Pleistocene, when dire wolves, various bears, jaguars, cheetahs, lions, and saber-tooths also roamed the continent. This diversity of mammalian carnivores is by no means exceptional; Europe, Asia, Africa, and South America either did or still do support similarly diverse carnivore guilds. In all these regions, the broad cat and dog niches are subdivided according to size, prey type, and habitat, allowing many species to coexist.

Biologists have long speculated on the cause of the imbalance in the Meganesian mammal fauna. One of the most important limitations known to affect carnivores is simply the size of the landmass they inhabit. Although Australia, which comprises the bulk of Meganesia, is indeed the smallest continent, it is still about 3 million square miles in area. Yet the Megane-



Erwin and Peggy Bauer; Bruce Coleman, Inc.

A pair of dingoes fight, below. Wild dogs whose ancestors were introduced into Australia about 3,500 years ago, these newcomers contributed to the extinction on mainland Australia of native marsupial carnivores, such as the Tasmanian devil, left.

Jean-Paul Ferrero/AUSCAPE International



sian carnivore assemblage is not much richer than that of the island of Madagascar, which is only one-twentieth the size of Meganesia.

Another school of thought holds that marsupials, having relatively small brains, were unable to evolve into successful predators. A quick look at the fossil record of South America, however, disproves the hypothesis that a connection exists between brain size and predation skill. Many species of doglike marsupials, ranging in size from bearlike to civetlike, lived in South America during the Tertiary period, about 65 to 2 million years ago. A remarkable subfamily of carnivorous marsupials evolved into catlike animals, resembling North American saber-tooths, that were capable of killing the largest of prey. The group that includes the ancestors of the American opossum also produced large flesh eaters. While all of these beasts became extinct when placental carnivores arrived in South America over the past 5 million years, they thrived for many millions of years, preying mainly upon large placental herbivores.

Since there appears to be no intrinsic bar to carnivory in marsupials, perhaps the environment holds a clue to Meganesia's paucity of large carnivorous mammals. Meat eaters sit at the apex of a broad-based food pyramid and are thus the most vulnerable of life forms to disturbances in the food chain. For example, an area of grassland that supports billions of individual grasses may sustain only a few thousand large herbivores. These, in turn, may be able to support fewer than one hundred large carnivores. If the environment is poor, large herbivores will be rare and thinly spread, and a critical point may be reached where the density of prey is so low that a population of large meat eaters cannot be sustained. If further impoverished, such an environment can no longer support any large carnivores.

Australia is notoriously infertile. An old continent with a stable geological history, it has experienced no widespread glaciation, mountain building, or volcanic activity—the forces that create new soil—over the past 50 million years. As a result of its quiet past, Australia is a land of old, thin, and leached soils. In the country's semi-arid zone, for example, soils have about half the levels of nitrates and phosphates of equivalent soils elsewhere. The amount and quality of arable land is another good measure of productivity, and even the 10 percent of Australia's total land area that is considered arable is marginal when compared with other landmasses. Other indications of poor soil come from Australia's plants, which have developed a variety of strategies, including slow average growth rates, to cope with the lack of nutrients.

A contributing environmental factor is El Niño, or the Southern Oscillation cycle, which influences rainfall with a periodicity of roughly a decade. In some years, Australia receives high levels of rainfall, and productivity peaks, as it did in 1990. But in El Niño years, such as 1992, rainfall is reduced and prolonged droughts are likely. On no other continent does the cycle have such an extreme impact. Its effects can readily be seen in the high degree of nomadism and nonseasonal breeding in many Australian animals, particularly birds. When such variability is superimposed on a system that is already marked by low productivity, top-order carnivores are subject to exceptional stress.

These climatic factors have so shaped the biology of the region that even areas of rain forest lack big carnivores. The largest area of rain forest in Meganesia is in New Guinea, which is even more noteworthy than Australia for its lack of meat-eating mammals. Here we have no evidence of indigenous large catlike or scavenging predators. Before human settlement, New Guinea supported some two hundred species of rather small mammalian herbivores and insectivores, but was home to just one large warmblooded carnivore, the thylacine. Today, apart from humans, the largest predator is the bronze quoll, a two-pound, civetlike species.

If large meat-eating mammals are disadvantaged in such a system, might animals that require less food and energy fare better? Reptiles eat far less than mammals do, having no need to create inner body heat. They can survive long periods of food shortage and can exist at higher population densities than mammals, relative to their prey. Coldbloodedness thus becomes a great boon to survival. I believe this is what has happened in Meganesia, home to a remarkable array of carnivorous reptiles. Before the arrival of humans, the largest carnivores in the region were *Won-*

The world's largest living monitor lizard and a formidable predator, the 250-pound Komodo dragon, below, is only a fraction of the size of Australia's extinct goannas. In an Australian Ice Age scenario, right, the drowned body of a rhino-sized diprotodon attracts the neighborhood's top predators. Megalania, *(a giant goanna) and a saltwater crocodile vie for the carcass as* Wonambi, *a pythonlike snake, lurks on the sidelines. The land crocodile* Quinkana *approaches, eager to scavenge any scraps.*

Christian Grzimek/Okapia; Photo Researchers, Inc.



ambi, a 110-pound pythonlike snake with a 12-inch girth; a giant land crocodile known as *Quinkana*; and a goanna—a kind of monitor lizard—called *Megalania.* Weighing as much as a ton, and more than twenty feet long, *Megalania* would have dwarfed present-day reptiles. Its nearest living relative is the Komodo dragon, which lives on a few small Indonesian islands adjacent to Australia. Although it weighs only a fraction as much as *Megalania,* the Komodo dragon is capable of killing goats, calves, and even humans. *Megalania* would have been powerful enough to subdue diprotodons, the rhino-sized marsupial plant eaters that were the largest of all Australian mammals. *Wonambi,* the snake, occupied a far different ecological niche. It lived much farther south than large snakes do today and its remains are often found in rocks and caves. Its head was enormous; its jaws filled with hundreds of tiny teeth. It may have fed upon wombat- and wallaby-sized mammals. The least well known of these reptiles is the 10-foot long, 500-pound crocodile *Quinkana.* It seems to have been quite independent of water, for its fossils have been found in caves that contain only remains of terrestrial species. *Quinkana* had a large, boxlike snout and compressed, serrated teeth. It may have competed with young *Megalania* for the now extinct kangaroos and smaller diprotodons.

Are the climatic patterns of the Pleistocene and more recent times an aberration in the history of Meganesia? Paleontological research suggests that during much of the "age of mammals," and certainly since about 20 million years ago, Meganesia has been relatively resource poor and lacking in mammalian carnivores. On the other end of the spectrum, leading into historic times, Meganesia has been colonized by humans and, more recently, by animals introduced by them. How have the predators among them fared? The number of humans in Meganesia since people first crossed the sea from Asia some 40,000 years ago remained small prior to European settlement. Adaptable and omnivorous, humans also became the top predators; their hunting prowess probably led to the extinction of all terrestrial vertebrate species that exceeded them in size, including all of the land carnivores larger than the thylacine. The dog known as the dingo, introduced some 3,500 years ago, apparently drove both the thylacine and Tasmanian devil to extinction on the mainland. The success of other smaller, introduced predators such as the fox has been detrimental to native predators such as quolls. Humans, dingoes, and foxes have not caused a net increase in the number of mammalian carnivores in Meganesia; they have simply replaced the few existing warmblooded carnivore species. But today, Australia, Tasmania, and New Guinea can still boast a rich supply of reptiles—ten species of goannas and a further ten species of pythons that weigh at least ten pounds. This remains a record number of sizable coldblooded carnivores.

The case of the Meganesian meat eaters opens up new areas for exploration while reinforcing the view that because of its unusual climatic conditions and long isolation, Meganesia is truly a separate experiment in evolution. □





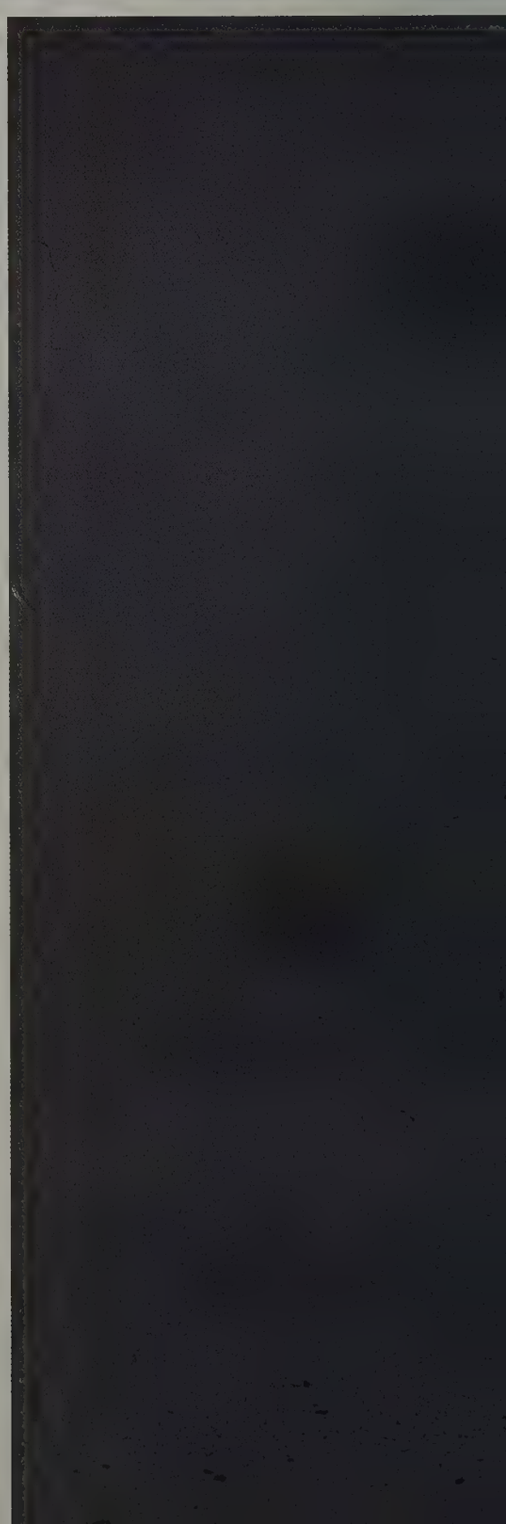
Tern Turn-on

Text and photographs by Bruce McMillan

After courtship dances in flight, the moment of truth has come for this pair of least terns on a beach in southern Maine. The male, parading around his mate while flicking his bill, shows off his nuptial gift of a fish, a sand lance. When he finally gets the response he wants, he tentatively approaches the now-crouched female from behind. She turns her head and eyes the fish, and he hops onto her back to offer her the prize. As she grabs it, he lowers himself onto her and releases his sperm into her cloaca.

But is he fast enough? Once she has a firm grasp of the fish, the female sometimes flies off before fertilization has taken place. These birds, however, will try again and again during the breeding season, and if they are lucky, they will produce a chick or two.

For least terns, every new hatchling is important. Once, these terns were a common sight along the Atlantic and Pacific coasts and in the south-central river basins. But overhunting in the late 1800s reduced their populations to dangerously low levels. In the early 1900s, protected by legislation, they made a comeback, but development subsequently destroyed much of their habitat. Today, least terns are endangered. Their nests, exposed scrapes in sand, are vulnerable to being trampled by people and preyed upon by cats, rats, gulls, and dogs. Fewer than 150 pairs of least terns now return to breed in Maine, the northernmost boundary of their range. □



©1993, by Bruce McMillan, from *A Beach for the Birds*, Houghton Mifflin

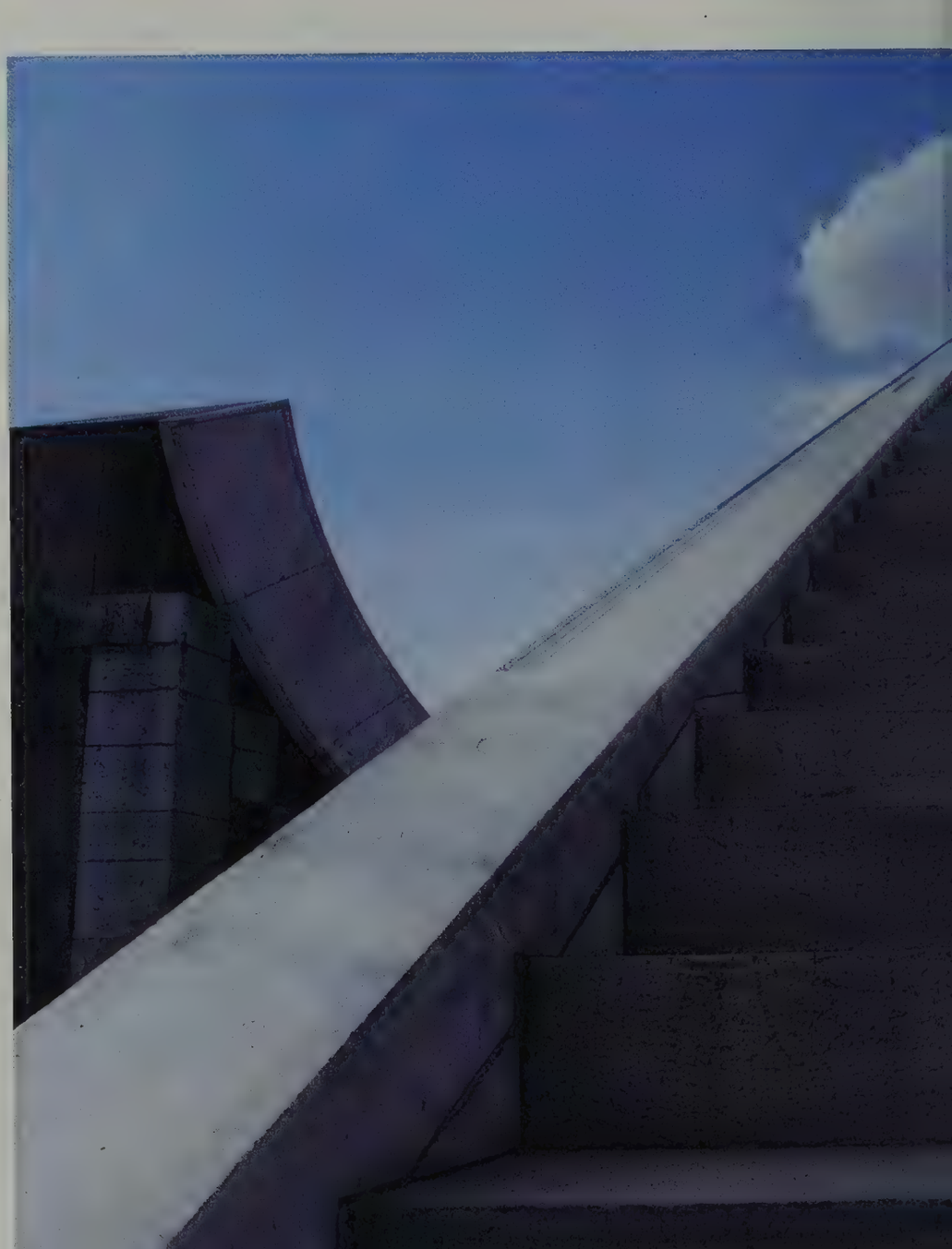




Stairways to Heaven

A maharajah's stone observatories built in the 1720s served the religious and secular needs of India's Hindu and Muslim rulers

by Peter Engel



Walking through the astronomical observatory at Jaipur, one of five built in northern India by Maharajah Sawai Jai Singh II almost three centuries ago, I felt an odd sensation, one I had never felt before. The stone was cold on my bare feet; the low, early morning sun had not yet warmed the earth. In the dawn light, the enormous structures surrounding me were little more than silhouettes anchored deep in the earth. When the shade lifted, shafts of light raced across the ground. Staccato rhythms of light and dark covered the surface of the structures that encircled me. As I climbed their winding steps, penetrated their dark recesses, and passed beneath their empty portals, the sun seemed to bring them to life.

Built to observe the heavens, these structures are now counted among the world's great works of architecture and are regarded as one of the highest achievements of Indian astronomy. Jai Singh's observatories resemble nothing in our ordinary experience. Few people, apart from a handful of scholars, know their history or understand how they work. Considering his accomplishments in astronomy, their builder, Jai Singh, is equally obscure.

In modern observatories, such as those perched atop Mauna Loa in Hawaii, the buildings house instruments for observing the sky. In Jai Singh's observatories, however, the buildings *are* the instruments. He erected his largest observatory in Jaipur, the capital he built and named after himself, and located the others in Delhi, Varanasi, Ujjain, and Mathura. In appearance, they are geometric hybrids. Familiar shapes—hemispheres, arcs, sections of cylinders, and fragments of cubes and isosceles triangles—have been subtly recombined to make new forms, some of the most beautiful I have seen. In all, Jai Singh constructed three dozen instruments, each designed for making specific astronomical measurements.

These observatories had their origins in 1719, when Jai Singh, then thirty-three years old, approached the Mogul emperor Muhammad Shah with a proposal to build them. Although the Moguls, who were Muslims, had ultimate control over many of India's most prosperous states, some were under the hereditary rule of Hindus such as Jai Singh. A contemporary portrait of Jai Singh shows him in a reflective mood, dressed in a brilliant aquamarine robe and a scarlet turban. His features and adornments reflect his Rajput caste: a straight, narrow nose, eyes shaped like almonds, jeweled earrings, and an ample mustache. In time he would govern much of northern India, including such ancient centers of learning as Agra, Varanasi, and Ujjain. In addition, he was building a reputation as a brilliant soldier and a clever statesman. He would establish himself as

The smaller of two large sundials constructed at Jaipur, this Samrat Yantra can tell time to within twenty seconds.
Robert Frerck; Odyssey Productions



the most enlightened of despots, a patron of the arts and architecture, and a scholar. Chief among his scholarly passions were the mathematical sciences and astronomy.

The need for the observatories, Jai Singh told the emperor, was immediate, as the astronomical tables used to plan the "very important affairs regarding religion and the administration of the empire" were far from accurate. The astronomers in Muhammad Shah's court, who tracked the moon and sun, used the tables to reconcile disparities between the two different systems of timekeeping then in use, the lunar and solar calendars. The calendar favored by the emperor—called the hegira because it originated at the time of the Prophet Muhammad's flight from Mecca in A.D. 622—was based on the period of the moon's orbit around the earth. The calendar followed by the emperor's Hindu subjects, however, was the vikramasamvat, which dated to 58 B.C. and was based on the period of the apparent revolution of the sun around the earth (Jai Singh, like the emperor and his subjects, believed that the sun orbited the earth). In converting from one system to the other, there were always days, hours, and minutes left over. (We still use leap years and unequal months to resolve this inconsistency.)

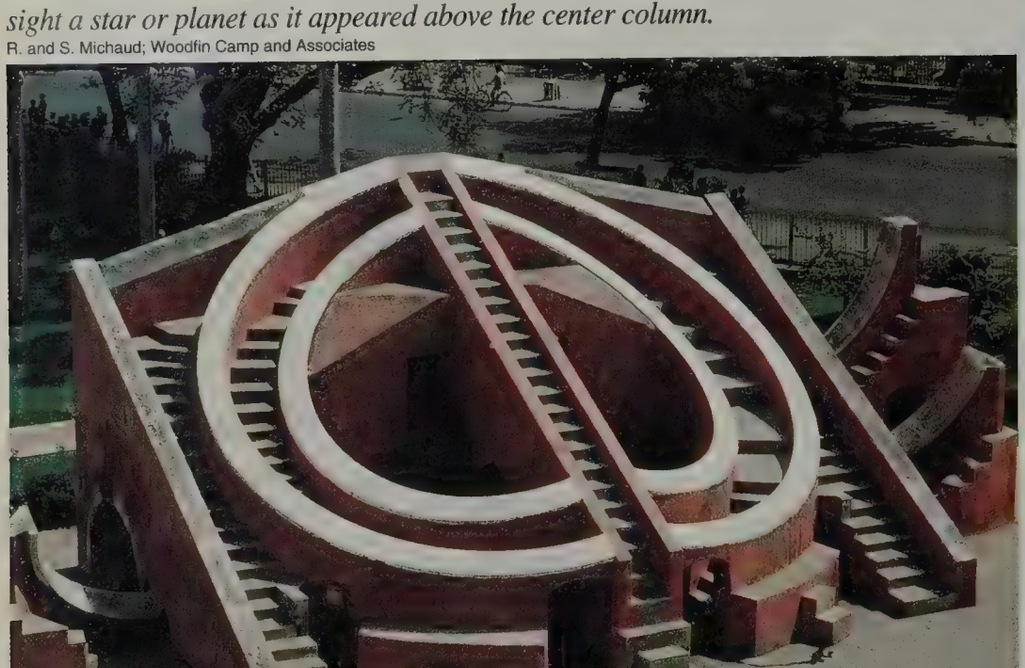
Keeping an accurate calendar was essential to the practice of religious rites and duties associated with the motions of heavenly bodies. Despite their different religions, Muhammad Shah and Jai Singh attached great importance to the rising and setting of the sun, the phases of the moon, the passage of the seasons, and events that were considered particularly ominous, such as lunar and solar eclipses. Like most of their subjects, both men believed that the entire course of people's lives could be predicted from the configuration of the celestial bodies at the time of their birth—assuming, of course, that the astronomical tables were correct. Science and mythology mingled as easily in India as they did in Europe, where astrology still flourished despite the discoveries of Copernicus, Kepler, and Galileo.

A second essential function of the astronomical tables was the timing of civil affairs. One particular challenge the emperor faced was how to administer the Moguls' enormous tax system. Land revenues were traditionally collected after the harvest, when there was food to be taken, and since the harvest was a seasonal event, its timing had to be determined using the solar calendar. Jai Singh pointed out to the emperor that, based on his own observations, the official tables failed to predict with sufficient accuracy the appearance of the new moon, the brief moment in the moon's rotation around the earth when the side of the moon facing the earth is completely dark. Even a slight error in this

Robert Holmes

The Misra Yantra in Delhi, below, is a composite of five different instruments for making various celestial measurements. One of two parts of the Ram Yantra in Delhi, the instrument at right was used to measure the altitude and azimuth of celestial objects. Standing between the radiating marble strips, the observer would lean over to sight a star or planet as it appeared above the center column.

R. and S. Michaud; Woodfin Camp and Associates





computation would be enough to throw off the lunar system of timekeeping. If the two calendars could not be reconciled, the orderly collection of revenues and other affairs of state would be jeopardized.

With the flaws in his astronomical charts exposed, the emperor consented to Jai Singh's plan to correct the situation. Perhaps the urgency of the request was enough to persuade the emperor, or perhaps the opportunity to name a new calendar era after himself prompted the decision; all we know for certain is that the year 1097 of the Muslim calendar was henceforth to be known as the first year of the reign of Emperor Muhammad Shah—and the year in which construction of India's first astronomical observatory was begun.

Jai Singh began by reviewing the astronomical sources that had been used to assemble the tables of Muhammad Shah. He consulted Hindu tables that dated back to the ancient *Vedas* (now believed to have been compiled at least a thousand years before Christ). He examined Islamic tables that were based on the work of the Greek astronomers Hipparchus and Ptolemy. He even ordered a Sanskrit translation of Ptolemy's *Almagest* (the original was in Greek, but it had come down to him in Arabic).

Jai Singh sent his emissaries to the centers of Islamic scholarship to bring back the most accurate astronomical instruments they could find. The devices that Greek, Islamic, and European astronomers had used to observe the heavens were similar to those used at sea for navigation: sundials, sextants, astrolabes, and armillary spheres. Extraordinarily crafted, with the intricacy of a Persian miniature, most of these instruments were small enough to be held by hand; the few larger ones, like the nineteen-foot quadrant designed by Danish astronomer Tycho Brahe, were mounted on platforms and pivots. Jai Singh studied these instruments in detail and had his artisans replicate them for his own use.

Next, Jai Singh turned his attention to the newest European research in astronomy. His emissaries returned with star catalogs and other astronomical books based on observations from such trustworthy sources as Brahe and the new observatory in Greenwich, England.

One day, one of his emissaries, the Portuguese Jesuit Padre Manuel de Figueiredo, returned with a telescope, the curious device that Galileo had trained on the heavens to make all sorts of astounding discoveries in the early 1600s. It was not the first one to reach India, but Jai Singh became the first Indian to use a telescope for astronomical purposes. With it, he duplicated Galileo's observations. He saw that Jupiter has four large moons; that



the sun has spots that rotate around its surface; that Venus and Mercury have phases just like the moon's, meaning that they too receive their light from the sun; that Saturn has an odd, elliptical appearance (he did not know that it was caused by rings); that the orbits of the moon and sun around the earth (really, the orbit of the earth around the sun) are not circles, but ellipses; and that the supposedly fixed stars appear to move ever so slightly, with differing velocities, thus confirming a phenomenon known as the precession of the equinoxes. Perhaps most important for his own purposes, Jai Singh was able to observe the new moon's first rays even when they were not visible to the naked eye, enabling him to establish a new standard of precision for the emperor's new calendar.

Fond as he was of his brass instruments, Jai Singh remained dissatisfied. He blamed the inaccuracies in the existing astronomical tables on the instruments' mechanical limitations, noting in particular "the smallness of their size, the want of division into minutes, the shaking and wearing of their axes, the displacement of the centers of the circles, and the shifting of the planes." In his studies of the old texts, Jai Singh had come across descriptions of giant stone instruments (one was alleged to be as tall as the dome of Hagia Sophia, in Constantinople) that the fifteenth-century Turkish ruler Ulugh Beg had constructed at Samarkand. And so, midway through the construction of his first observatory, he changed his strategy.

There were many advantages to making the instruments large. On a garden sundial, the shadow of the triangle falls on markings, etched into the base, that indicate the hour of day. Jai Singh's largest sundial, which he called the Samrat Yantra, or "Great Instrument," has a stone triangle nearly 90 feet tall and 150 feet long. As the sun arcs across the sky, the giant triangle casts a shadow on one of the two marble quadrants rising from its sides. Because of the instrument's enormous size, the shadow moves at the rapid pace of about two millimeters a second. This means that the Samrat Yantra can measure the time of day to within two seconds.

The Samrat Yantra is the largest and perhaps the simplest of the instruments, but the same principle, enormous scale, is basic to all of Jai Singh's designs. Many, including the sundial, are original inventions of Jai Singh and his chief astronomer, Jagannath. Others are enlargements of the brass instruments in Jai Singh's collection.

Why Jai Singh built so many observatories is not known with certainty. The Jaipur observatory, the largest and most varied of the five, has fourteen instruments, followed by the one in Delhi, which has ten. The others contain a half



Lindsey Hebberd; Woodfin Camp and Associates

Jaipur's large Samrat Yantra, left, is the largest sundial ever constructed and can tell time to within two seconds. On the grounds of the Jaipur observatory, below, Jai Singh holds an astronomical book presented to him by a Portuguese Jesuit, Padre Manuel de Figueiredo.

Suraj N. Sharma; DPA Courtesy of Maharaja Sawai Man Singh II Museum, Jaipur



dozen or less, and most of these duplicate the ones at Jaipur or Delhi. Perhaps Jai Singh wanted the increased accuracy that comes from taking measurements from several different points or perhaps he was simply experimenting, hoping for improvements with each new instrument. The Jaipur observatory, for instance, has two Samrat Yantras, and the smaller one preceded the construction of the one that is exactly ten times its size.

Jai Singh employed so many types of instruments because two different coordinate systems are needed to keep track of motions in the sky. The first is centered on the observer and measures the position of a heavenly body as seen by the observer against the sky. To locate the precise position of an object in this system, the information needed is the object's altitude, its height above the horizon measured in degrees (90° is directly overhead), and its azimuth, or compass direction.

But because of the earth's continuous rotation and its revolution around the sun, measurements based on the observer are good only for the instant in which they are made: in the succeeding moment, the motion of the earth has rendered them out of date. A second measuring system is needed, one with fixed coordinates in the sky. In this system, an imaginary "celestial sphere" with the stars painted on its surface surrounds the earth. Its coordinates are an extension of the earth's. The pole of the earth pierces the celestial sphere at the celestial pole, and the earth's latitude and longitude lines are projected outward onto the sphere's surface, where they are called declination and right ascension.

The observer's system can only be converted to the system based on the celestial sphere by knowing the position of the observer on the earth and the precise time of the measurement. Even then, the process of conversion is extremely time consuming and complicated, involving a thorough knowledge of trigonometry and spherical geometry. Jai Singh realized that by incorporating the conversion calculations into the design of the instruments, his astronomers could bypass the need for repeated hand calculations.

The design of the instruments was determined not only by celestial but also by mundane considerations. For example, the arched openings in the Samrat Yantra prevent it from toppling over in strong winds. The instruments also had to be built to a human scale, so observers could take measurements. The Samrat Yantra has steps on both the quadrants and the hypotenuse of the central triangle that allow the observers to reach the stone railings on which the markings are etched.

Mundane considerations also explain the form of the Jai Prakash Yantra (Jai [Singh's] Instrument of Light), which consists of two complementary components that must be used together. Two hemispherical bowls are set into the ground, side by side. Each represents the inverted hemisphere of the sky with coordinate lines inscribed in the marble surface. Stretched across the top of each bowl are two crosswires from which a central ring is suspended. When a star or a planet is sighted through the ring, the position of the observer's eye held close to the surface of the bowl determines the object's coordinates in the sky.

Two complementary bowls are necessary because in a completely smooth, intact bowl an observer could not get into a comfortable position to make precise recordings. The surface of each bowl is therefore broken up by channels that function as walkways; the channels in one bowl correspond to the intact portion of the other bowl. If the line of sight falls upon an intact surface, the observer can lean over it and take a precise reading of the coordinates. (A pointer or a hollow tube can also be used to improve the accuracy of the reading.) If the line of sight happens to fall into one of the channels where there are no coordinates, the observer simply crosses to the next bowl, where the line of sight will of necessity fall on an intact surface.

In Delhi, the Ram Yantra (Ram's Instrument, named after a former maharajah, Ram Singh) similarly consists of two parts, in this case two enormous cylinders, and is used to measure the position of stars and planets. Each is walled by thirty thick columns alternating with thirty sets of arched openings. At the center of each cylinder is an enormous stone peg. Radiating from the base of each peg, like slices of cake, are thirty triangular sectors of stone alternating with thirty open walkways of the same shape. Each stone sector, like each arched opening in the wall, thus

Robert Frerck; Woodfin Camp and Associates



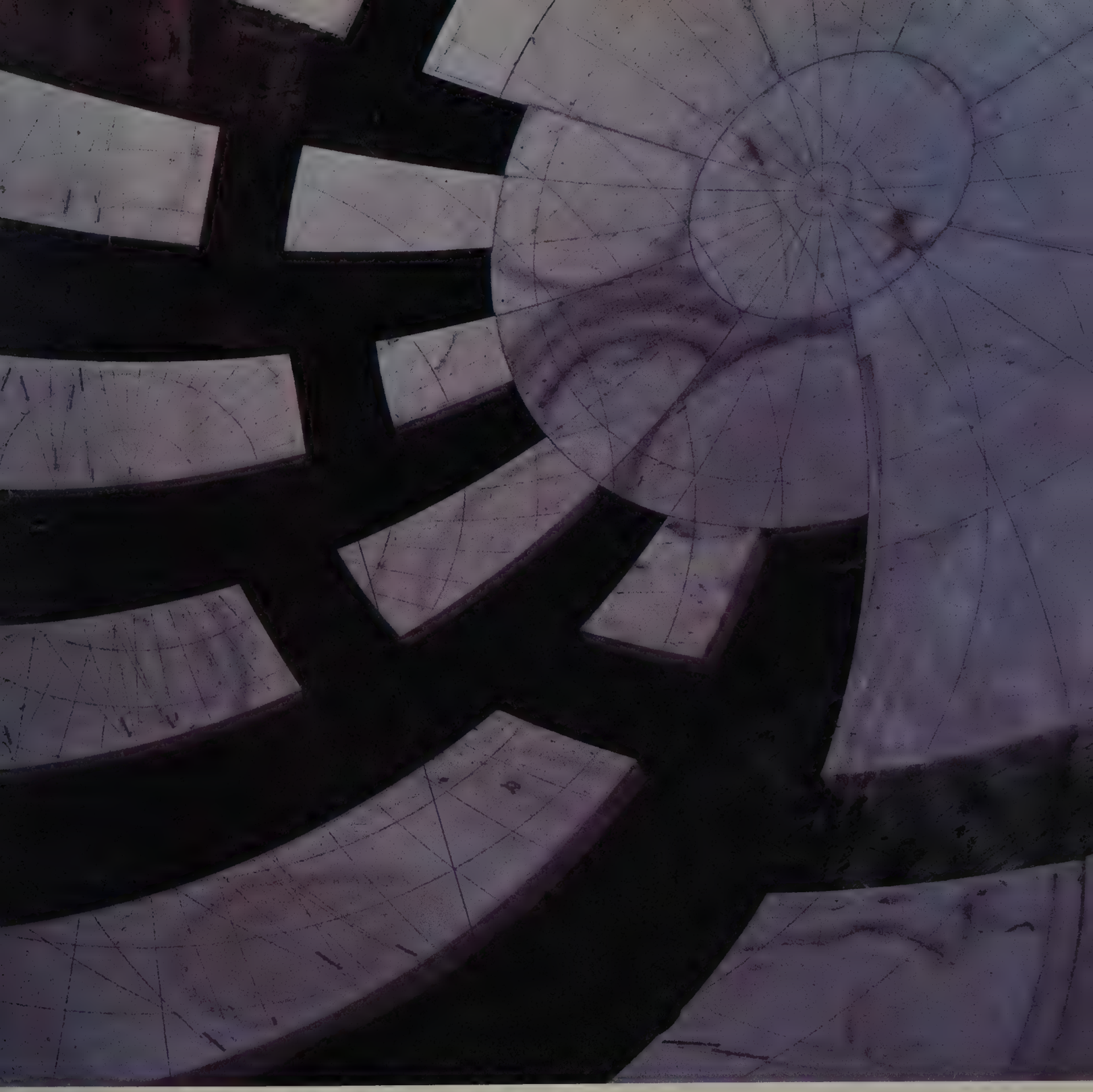
measures 6° of arc. The sectors are further subdivided into minutes of arc by markings on their surface, while notches in the wall next to the openings can hold measured metal bars. To take readings, the observer stands against the central column and notes the position of a celestial object, the openings in the wall revealing its altitude and the stone sectors its azimuth. As with the Jai Prakash Yantra, if a line of sight is blocked by a column in the wall, or if it falls on a walkway instead of a marked surface, the complementary cylinder is guaranteed to work.

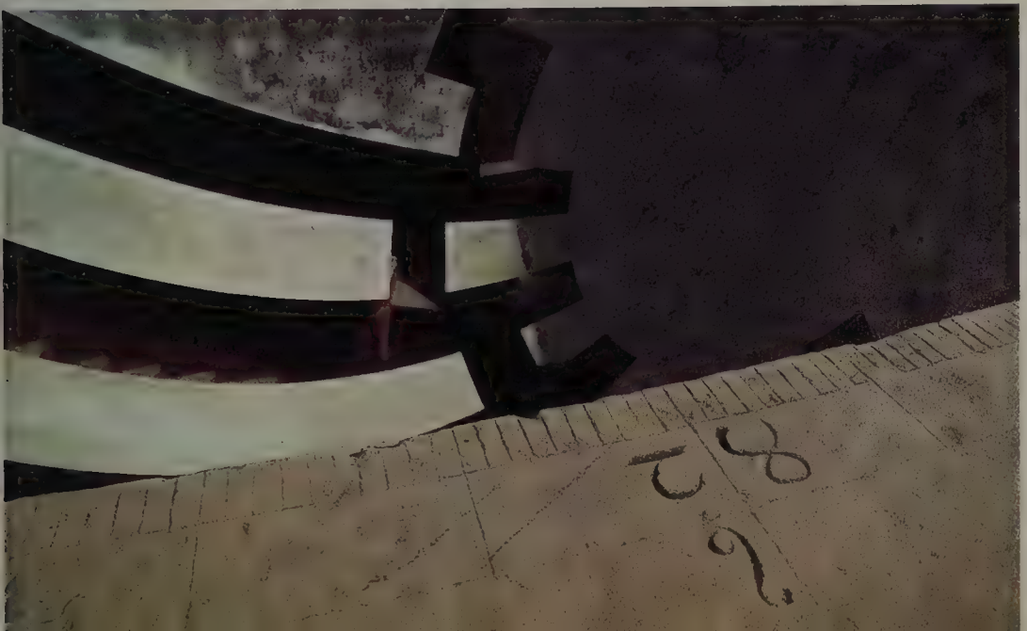
Jai Singh needed to know the time of day in other parts of the world, particularly in those places where the astronomical tables he was relying on were compiled. Of course, he could calculate this information by knowing the time of day at one of his own observatories and the difference in longitude between the foreign location and his own observatory, but he preferred to construct a device that would give him the information instantaneously. For this purpose, he created the Misra Yantra (Composite Instrument), at first appearance the oddest and most complex of all his devices. (It may have been constructed by his son after Jai Singh's death.) With its vertical triangle and curved quadrants, it duplicates the Samrat Yantra, but less precisely. Unique to the Misra Yantra, however, are two pairs of semicircular arcs on either side of the central staircase. Each arc lies in the meridian (a vertical plane passing in the north–south direction through the observer) of a different foreign observatory: the well-known Greenwich and Zurich observatories and, according to tradition, two others, one supposedly located in a village in Japan and the other on an island in the Pacific.

To operate this instrument, one observes the shadow cast on each of the four arcs by a metal peg at the center. (Because the two pairs of arcs have different centers, two pegs are required, one on either side of the stair.) When the sun rises, it casts the shadow of the peg on the two western arcs; when it sets, the peg's shadow falls on the eastern arcs. Markings on the arcs indicate the declination, the angular height above the celestial equator, of the sun for each foreign location. At a different time of day for each observatory, the shadow of the peg indicates that the sun has reached its maximum declination, or noon, allowing any other time of day to be deduced.

One of the greatest challenges faced by astronomers before Jai Singh was how to determine the coordinates of an object on the celestial sphere directly, without converting from the observer-based system. Because the earth's axis tilts with respect to its orbit around the sun, the sun's apparent orbit around the earth, called the ecliptic, inclines to the earth's equator at an angle of a little more than 23°. At any given time of day or night, one can align the hypotenuse of a triangle with the pole of the ecliptic, just as the hypotenuse of the Samrat Yantra's stone triangle aligns with the pole of the earth. But whereas the direction of the earth's pole remains constant, the direction of the pole of the ecliptic is continually on the move, its apparent movement caused by the earth's rotation. As a result, a single fixed instrument is incapable of making continuous direct measurements on the celestial sphere.

Jai Singh's ingenious solution was to devise the Rashivalayas Yantra (Divisions of the Zodiac Instrument). This one instru-





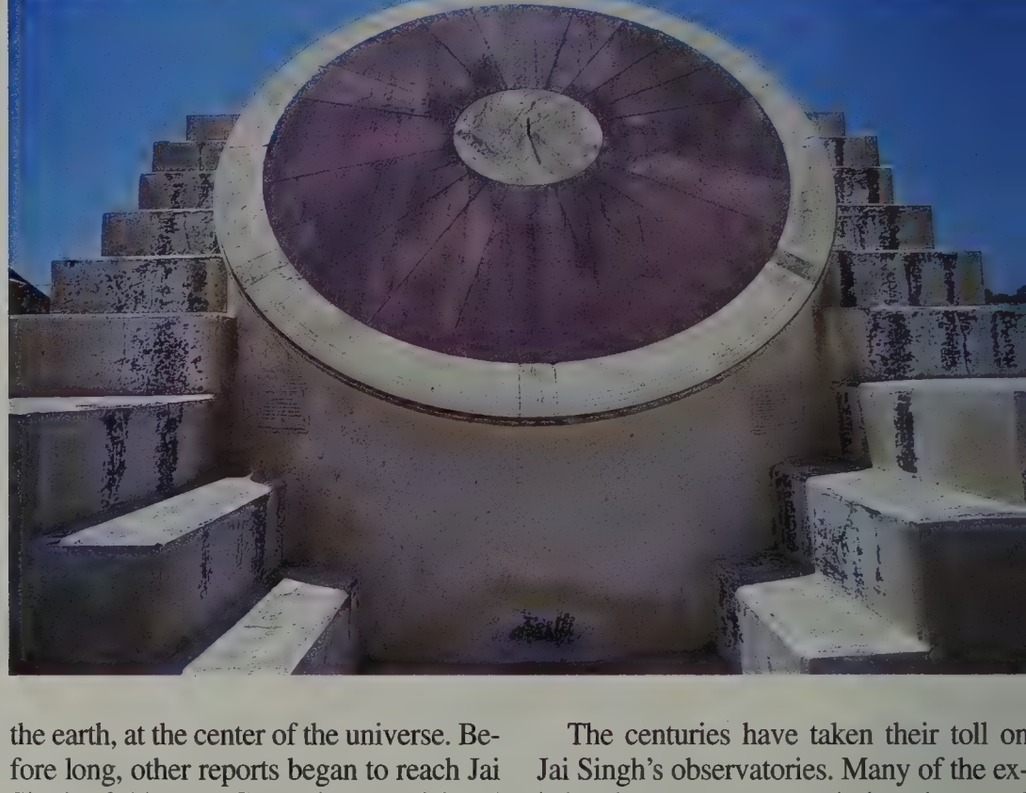
The bowl of the Jai Prakash Yantra in Jaipur, above, represents the celestial sphere. The small suspended ring through which stars and planets are sighted is visible near the top. On the edge of a similar instrument in Delhi, left, the degrees of the compass are etched in marble.

Robert Holmes

Erica Lansner; Black Sta

The northern face of the Narivalaya, another type of sundial, below, is used from March 21 to September 23, when the sun is in the Northern Hemisphere. A complementary sundial on the southern side is used during the fall and winter months. A stairway alongside one quadrant of the giant sundial at Jaipur, right, allows observers to read the markings on the marble slabs.

Robert Holmes



ment consists of twelve separate structures, one for each of the zodiacal signs. The zodiacal signs are the twelve constellations that fall along the ecliptic, dividing its circumference into twelve equal portions. Because the earth rotates through the full circumference in twenty-four hours, a new zodiacal sign comes upon the local meridian every two hours.

Although each of the Rashivalayas devices superficially resembles the Samrat Yantra, there is a crucial difference. Whereas the hypotenuse and quadrants of the Samrat Yantra are based on the coordinate system of the observer, the hypotenuse and quadrants of the Rashivalayas are oriented with respect to the celestial sphere. Each of the Rashivalayas devices points in a slightly different direction and is designed to be used during a different two-hour period of the day. When a given zodiacal sign falls along the local meridian, it is a signal that the hypotenuse of the corresponding Rashivalayas aligns with the pole of the ecliptic at exactly that moment. Observations must be made within a minute or two, before the time of alignment passes. By comparing measurements taken at two-hour intervals and interpolating, it is possible to track the movements of the planets on the celestial sphere.

By 1737, eighteen years after he had begun, Jai Singh's work was virtually complete. He put the finishing touches to the *Zij-i-Muhammad Shahi,* the "Astronomical Tables of Muhammad Shah." Two years after he dedicated this work to the emperor, however, Delhi was sacked and plundered and Muhammad Shah dethroned. The plunderer carried off all of Jai Singh's brass instruments; only their enormous size saved the stone ones.

Having survived one attack, the stone instruments were subjected to another, stronger assault, from a different quarter. In 1730, one of Jai Singh's emissaries had returned from Europe with a book that had been published just five years earlier, Johan Raptist Hoemann's *Great Atlas of the Whole World.* This book contained a curious chart showing the sun, instead of the earth, at the center of the universe. Before long, other reports began to reach Jai Singh of this new Copernican model and of the three laws of planetary motion contributed by Johannes Kepler, ideas that were gaining wide acceptance in Europe. Faced with a compelling theory that directly contradicted his own, Jai Singh went with the theory that lay closer to his heart, and despite an attempt to incorporate into his own theory Kepler's first law (that the planetary orbits are ellipses, not circles), he never gave up believing that the earth is at the center. When he died in 1743, at the age of fifty-seven, he could not have known that he chose wrongly.

Jai Singh's failure to accept the heliocentric model spelled the demise of stone instruments as useful tools for astronomical observation. In a cruel irony, an inaccurate instrument cannot detect the subtle differences in the planetary movements that mark the geocentric theory as incorrect; only instruments of the caliber of Jai Singh's could show that their manufacturer's vision of the universe was wrong. While other astronomers learned to adjust for the new theories by rebuilding or recalibrating their metal instruments, the giant stone instruments that had once been the best in the world became obsolete.

The centuries have taken their toll on Jai Singh's observatories. Many of the existing instruments are missing the metal pins and crosswires they need to function, while the weight of the upraised stone in the quadrants of the Samrat Yantra in Jaipur has distorted their curvature, rendering some of the measurements inaccurate. The observatory at Mathura has disappeared completely, the victim of plunder or the ravages of time.

Today the observatories also face a different and more insidious danger: becoming a cultural cliché. Contemporary Indian architects often echo the curves of Jai Singh's instruments in concrete, but they lack the purpose, craftsmanship, sense of proportion, and spiritual underpinnings of the originals. A caricatured image of the Misra Yantra was the official symbol of the 1982 Asian Games held in Delhi, appearing on banners, posters, and coins. And while the symbol of the observatories is held high, the buildings themselves continue to disintegrate or are being destroyed. In their rush to prepare for the Asian Games, government workers trying to keep water from collecting at the base of the Samrat Yantra poured concrete around it, submerging a portion of the two quadrants, perhaps forever. □



A special exhibition, **"The Dinosaurs of Jurassic Park,"** will open at the American Museum of Natural History on June 11 (see page 70).



*A termite (*Mastotermes electrodominicus*) in Dominican amber is 25 to 30 million years old. Museum researchers extracted DNA from a similar specimen.* ×5

Ed Bridges; AMNH

Forever in Amber

After 30 million years, an insect yields its DNA to Museum researchers

by David Grimaldi

Could *Jurassic Park* become reality? In the best-selling novel by Michael Crichton, an ambitious entrepreneur builds the ultimate theme park: a prehistoric landscape, complete with live tyrannosaurs and apatosaurs. These Mesozoic monsters have been brought to life by scientists who cloned DNA from dinosaur blood, which they obtained from the guts of blood-sucking flies preserved in amber.

A physician by training, Crichton presented details that made the science in his thriller seem credible. His major premise was inspired by the Extinct DNA Study Group at the University of California at Berkeley; among other goals, the group was trying to extract DNA from amber fossil insects. At the American Museum of Natural History, the team in the Molecular Systematics Laboratory—Rob DeSalle, John Gatesy, and Ward Wheeler—and I recently succeeded in amplifying and sequencing DNA from a 30-million-year-old termite preserved in an amber globule from the Dominican Republic. At about the same time, similar results were achieved by a joint research group from Berkeley and California Polytechnic University, and by Brian Farrell, of the University of Colorado.

While it is a long way from amplifying a bit of DNA to reconstructing a whole dinosaur—or even a termite—these new developments open up many exciting scientific possibilities. A few years ago, molecular biologists doubted that DNA could even survive for millions of years. Now it may be possible to compare genetic structures, along with fossil leaves and skeletons, opening up the possibilities for a new field: molecular paleontology.

In 1984, scientists were intrigued by the news that Allan Wilson's laboratory at Berkeley had cloned DNA from the hide of a quagga—the partly striped wild ass from southern Africa that became extinct about 110 years ago. Svante Pääbo, then at Wilson's lab, has gone on to become an authority on the study of ancient DNA. In 1985, Pääbo, now at the University of Sweden, extracted and sequenced DNA from a 2,500-year-old Egyptian mummy. Direct genetic comparisons between modern and ancient human populations were suddenly possible: whether, for instance, ancient Egyptians carried such deleterious genes as those for diabetes or sickle cell anemia.

The mummy's DNA survived because of the ceremonial practices of Egyptian morticians, who routinely removed viscera (and the bacteria within them) to prevent bodies from bloating and decomposing. Also, the cadavers were stored in a cool, very dry place, and the burial gauze contained astringents, such as pulverized amber, that helped extract moisture.

Dehydration is the common element among the success stories in the extraction of ancient DNA. The famous 5,200-year-old "Iceman" from the Austrian Alps (*see Natural History,* April 1993), probably died of exposure, then dehydrated in the cold, dry mountain air before becoming frozen inside a glacier. Researchers expect to extract DNA from his tissue samples. (The tissues of most corpses of modern hikers found in the Alps decompose into adipocere, or "grave wax.") Dehydration also preserved mammoth and other Pleistocene mammals from about 15,000 years ago, before they became frozen in ice. Mammoth DNA, analyzed by Russ Higuchi at the Cetus Corporation, shows that the extinct woolly tuskers were equally related to modern African and Indian elephants. Similarly, DNA was sequenced from a 14,000-year-old saber-toothed cat, whose remains were recovered from the La Brea tar pits in Los Angeles. Genetic studies of fossil bones corroborated some taxonomic relationships: the saber-tooth is closely related to living species of big cats.

Before the current work on amber insects, the oldest-known DNA was from 17-million-year-old leaves preserved in ancient lake sediments from Clarkia, Idaho. One was an extinct *Magnolia,* and the other was a bald cypress. Among the genes within the bald cypress's chloroplast DNA, one was very similar to genes of its living relatives, such as redwood. The DNA of the fossil *Magnolia,* however, was unexpectedly divergent from modern species. Both studies were possible because the Clarkia sediments were anoxic, preventing decomposition of the specimens (*see* "Magnolias from Moscow," *Natural History,* September 1992).

Fortuitous preservation of these fossils, however, was only half the battle. The other half was a marvel of new technology: a technique called polymerase chain reaction (PCR). PCR can make thousands of copies of minuscule quantities of DNA (even just a single strand), enough so that sequencing can be worked out. This technique is so sensitive, however, that it may also amplify contaminants, including bacteria or even the researcher's fingerprints.

One of the first indications that amber fossil insects might be a good source of ancient DNA came from electron microscopist Roberta Hess, working with her husband, George Poinar, in the Berkeley group. Hess prepared ultrathin sections of a sciarid midge (fungus gnat) found in Baltic amber and discovered organelles preserved within its cells. Researchers at Cambridge University also found microstructures that had not been seen be-

×50



A female no-see-um midge of an extinct species is preserved in 85-million-year-old New Jersey amber. Females of some modern species feed between the scales of snakes and lizards, so perhaps the midges on these pages dined on dinosaurs. But no amber specimen has been found replete with a blood meal.
David Grimaldi; AMNH

fore, including mitochondria—the repositories of female-inherited DNA. If the organelles were there, why not the DNA-containing chromatin? The race for amber DNA was on.

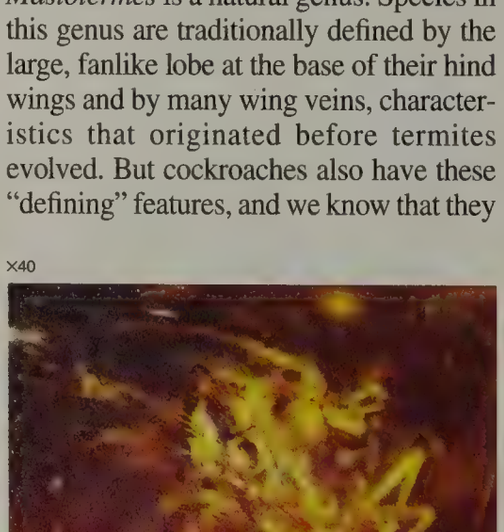
DNA is rarely preserved in mineralized or sedimentary fossils, but amber yields intact genetic material much more consistently. As sticky resin wept from ancient tree trunks and branches, insects that blundered into it became trapped, and small windblown flowers or pollen were enveloped. Some "amberized" creatures shrink and mummify, but many do not. Most decay, leaving husks that appear solid until the amber is dissected. Millions of years of polymerization hardens the amber and makes it virtually inert. Resinous compounds such as terpenes, which probably evolved as a tree's defense against insects, also help to prevent trapped insects from decomposing. Large deposits of 25- to 30-million-year-old amber—frequently containing fossilized organisms—are found on the Caribbean island of Hispaniola and in Chiapas, in southern Mexico. The largest, most studied deposits come from the Baltic Sea coasts and other parts of Europe, and are between 15 and 40 million years old.

Raoul Cano and his colleagues at California Polytechnic University examined amber specimens of an extinct stingless bee, *Proplebeia dominicana,* for a portion of the same ribosomal gene that we investigated for the termites. This group of bees has rudimentary ineffectual stingers and evolved into diverse species found throughout the world's tropics. Although *P. dominicana* is very common in Dominican amber, no native stingless bees live in the Caribbean today. Comparisons of the morphology of these creatures had led to controversies over relationships, so genetic sequences from the extinct bee are being compared with those from two living species from Central America. Such DNA comparisons may tell us whether the Dominican amber bee has its closest living relatives in Africa or in Central America.

Our first successful DNA extraction at the American Museum's laboratory was from an extinct termite that Kumar Krishna, a research associate, and I had recently described. We named it *Mastotermes electrodominicus,* "termite from the Dominican Republic with an electric charge" (in a reference to a familiar attribute of amber when rubbed). Other fossil species of *Mastotermes* occur in shales from North America and Europe and in Mexican amber, so we know that this genus once existed throughout the Northern Hemisphere. However, it has no living relatives anywhere except in northern Australia, where a thriving relict population is a notorious pest. (*M. darwiniensis*, named for the great naturalist, destroys wooden utility poles so rapidly that they have had to be replaced with concrete.)

When we attempted to extract and amplify DNA from the Dominican amber termite, we had two specific questions in mind. First, we wanted to know whether *Mastotermes* is a natural genus. Species in this genus are traditionally defined by the large, fanlike lobe at the base of their hind wings and by many wing veins, characteristics that originated before termites evolved. But cockroaches also have these "defining" features, and we know that they

×40



Male sandfly in Lebanese amber, about 120 million years old
David Grimaldi; AMNH

evolved well before *Mastotermes.* (That would be like defining humans on the basis of hair—a trait that occurs in almost all mammals and evolved well before humans.) To better establish the group as a real evolutionary unit, we needed to find traits that were exclusive to species in the genus.

The second question that concerned us was, is *Mastotermes* actually a "missing link" between roaches and termites? The traditional view—that termites are morphologically simple, myopic, wood-eating social roaches—is based partly on their roachlike wings and partly on how they lay their eggs. Unlike any of the 2,000 or so other living termites, *M. darwiniensis* in Australia lays its eggs in clumps of neat

×40



Female no-see-um in Lebanese amber, about 120 million years old
David Grimaldi; AMNH

rows. Most entomologists interpret these egg clumps as a rudimentary form of the cockroach egg sac.

After a lengthy search, I obtained specimens of *M. electrodominicus,* which is rather rare in Dominican amber, and brought them to the Molecular Systematics Lab. There, entomology curator Rob De Salle and postdoctoral researcher John Gatesy extracted and sequenced DNA for two genes, only one of which yielded key information. Invertebrates curator Ward Wheeler aligned its sequences with those of three other termites, including the living species of *Mastotermes*, as well as with a mantis, a cockroach, and three distantly related insects. We found several unexpected differences in the DNA sequences among the extinct and living *Mastotermes* termites. But biochemical information from the amber specimen did confirm that the extinct and living species of *Mastotermes* are closest relatives. Finally, genetic

ata also confirmed the status of *Mastoter-ıes* as more termite than roach—although t retains features of a distant ancestry that oaches, termites, and mantises share.

Because of our work with DNA from mber insects, I am often asked these days vhether the premise of *Jurassic Park* is ealistic. According to George Poinar at Berkeley, extracting dinosaur material rom a fossilized Cretaceous fly is within he realm of possibility. If one were earching for dinosaur blood, an amber-zed fossil insect would be an imaginative lace to look for it—but then the real diffi-ulties begin. Amplifying and cloning mi-uscule, undigested dinosaur DNA from he gut of a blood-sucking fly remains fic-ion, especially since red blood cells have ery little DNA. Consider the magnitude f the current effort to sequence the human enome (which is the entirety of human NA), for which billions of dollars, hun-lreds of researchers, and an almost infinite ource of fresh samples are available. Re-onstructing the genome of a dinosaur rom base pairs of DNA would be like try-ng to reconstruct Tolstoy's *War and Peace* from a gigantic vat of alphabet oup.

(By the way, devotees of Crichton's ovel may have noticed that he includes a NA sequence in the book that is suppos-dly part of a dinosaur's genetic code. Ac-ording to Mark Boguski, a molecular bi-logist at the National Institutes of Health, he sequence is that of one of the most ommon strands of fabricated DNA used n human genetic research.)

Will these new genetic techniques re-lace traditional detailed anatomical stud-es for tackling questions about evolution-ry relationships? The comparison of rganisms' structures will always be in-riguing and one of the most aesthetic ranches of study—although some molec-lar biologists have been known to wax entimental over the codelike patterns of ands on a gel. Bones, teeth, and insect wings are the products of thousands of genes and of complex interactions among them, and can be as good a source as mol-ecules in studying phylogenies. Yet the delicate insects trapped in amber, along with other special kinds of fossils, present a unique challenge: Their retrievable DNA sequences can shed a great deal of light on evolutionary questions that mor-phology alone sometimes cannot answer.

David Grimaldi, an associate curator of entomology at the American Museum of Natural History, specializes in the study of living flies and fossil insects.

×60



A centipede in amber from Chiapas, Mexico, is 25 to 30 million years old. Amber from Chiapas and from the Dominican Republic is of similar age and clarity.
Ed Bridges; AMNH

Planet X

by Gail S. Cleere

The search for new planets in our solar system may be nearing an end. Astronomers began speculating seriously about unknown planets following William Herschel's 1781 discovery of a fuzzy object that moved each night against the background stars. At first he and other astronomers thought it was a distant comet, but then they realized it was a new planet. Mercury, Venus, Mars, Jupiter, and Saturn had been known since antiquity, but this was the first time another "wanderer" had been found. In keeping with the traditions of naming the planets after mythological characters, the seventh planet was named for Uranus, the father of Saturn.

Roughly fifty years later, however, a mystery started to brew. Astronomers were finding that the calculated positions of Uranus, based on Isaac Newton's laws of planetary motion, did not match its observed orbit. What was causing the discrepancy? In 1834, Rev. T. J. Hussey, rector of Hayes, was the first to suggest, in a letter to Airy, the astronomer royal of England, that the orbit of Uranus was being perturbed by the gravitational force of an eighth planet. By 1845, John Couch Adams in England and Urbain Leverrier in France had independently calculated the position of the new planet.

Even with a predicted location, however, the search for an eighth planet was not easy. At the time, astronomers did not have accurate star charts, such as the Mount Palomar sky survey plates in use today; what was known about the predicted positions of the planets was not terribly accurate, and the astronomical photography we use today was in its infancy. Nevertheless, using a brand-new star catalog produced in Berlin, Johann Galle discovered the planet in 1846 based on the predictions made by Leverrier, and the name Neptune, god of the sea (already proposed once before for Uranus), was given to the new planet. That seemed to settle the matter for a while.

By the turn of the century, however, astronomers again showed that the observed orbit of Uranus did not match the calculated positions, even when Neptune was taken into account. Astronomers Percival Lowell and William Pickering concluded that there had to be yet another planet or planets in the solar system. In 1930, Clyde Tombaugh, at Lowell's observatory in Flagstaff, Arizona, discovered a new planet in roughly the position that Lowell had predicted it would be found. In Lowell's honor, the name given the new object, Pluto, began with his initials.

The mystery, however, did not end there. While Lowell's calculations of Pluto's position were roughly accurate, the position and mass of the new object did not fully account for the apparent perturbations of the orbits of Neptune and Uranus. As P. K. Seidelmann explains, "The effect of one planet on another is proportional to the mass, and inversely proportional to the square of the distance. We could more accurately determine the mass of Pluto once its satellite, Charon, was discovered [fifteen years ago]. Based on what we know today, Pluto is much too small to be capable of significantly perturbing Uranus or Neptune. Even Pluto itself seems to vary from its predicted position, although we've only been observing it for seventy-odd years and its orbital period is a total of 248 years."

Some astronomers, like Myles Standish, of California's Jet Propulsion Laboratory, do not believe the observations of Uranus and Neptune show anything unusual about the motions of those planets. They believe that any remaining inconsistencies come from the measuring process itself. Standish also discounts the possible role of the thousands of planetesimals, or miniplanets, that may be in the solar system's outer reaches. The recently discovered object 1992 QB1 (*see* "Celestial Events," February 1993) proved to be the first of these. Standish wrote in the June 1990 *Sky and Telescope* magazine, "Probably someday someone will find additional mass in the Solar System beyond Neptune, possibly even a sizable chunk." The debatable point, he tells us, "i whether anything is affecting the motion of the outer planets. I say nothing measu able—many astronomers, especially nov agree with me."

After discovering Pluto in 193(Tombaugh continued searching a larg part of the sky for objects down to 16t magnitude, but found nothing. Pionee space probes X and XI continue to trave outward in opposite directions in the sola system, but NASA says their motion ha not been affected by any unseen object The infrared astronomical satellite (IRAS has searched for objects radiating in the in frared but has found nothing conclusive s far, and we have heard nothing from th Hubble Space Telescope.

THE PLANETS IN JUNE

Mercury can be seen in the first half o June, just after sundown, very low on th northwestern horizon. Look for the sun closest neighbor just below the twin star Castor and Pollux, in Gemini.

Venus is our only morning planet thi month, rising a couple of hours before th sun. The planet is placed quite nicely a 20° above the eastern horizon by the tim the sun is up. Venus is visible just belo Hamal and Sheratan, the two brightes stars in the constellation Aries. On th 16th, the waning crescent moon, movin eastward by about 15° a night, pays a ca just above brilliant Venus and just belo Hamal and Sheratan.

Mars is now in the constellation Le and can be seen in the west–southwest jus after sunset. Watch as the red planet fa approaches the bright star Regulu throughout the month, reaching a magnif cent close conjunction (less than one de gree) on the 22d. On the 24th, the fou day-old moon sails by just below the pair

Jupiter continues to move throug Virgo, finally ceasing its retrograde (wes ward) motion through the constellation which began at the end of January. O June 1, Jupiter resumes its proper eastwar motion across the sky. (Retrograde motio

f the outer planets is the visual effect of he faster-moving earth overtaking the uter planets against the background tars.) On June evenings right after sunset, upiter can be seen just west of your local neridian, setting about five hours later. On he 27th, the first-quarter moon drifts 7° elow it.

Saturn rises after midnight, still among he faint stars of Aquarius. As the ringed lanet nears the meridian at sunrise, face outhwest and look high overhead to see he great Northern Cross, part of the con-tellation Cygnus the Swan. High above Saturn, but just below Cygnus, you will ee the tiny jumping dolphin, Delphinus, ne of the few constellations that actually ook like what they represent.

Uranus and **Neptune** continue to re-nain close together in eastern Sagittarius, ising about an hour and a half after sunset nd staying with us throughout the night binoculars and an accurate sky map are eeded to find them).

Pluto resides near the northern claw of Scorpius (now designated part of the con-tellation Libra). A fairly large telescope nd excellent sky charts are needed to lo-ate this distant planet.

The summer solstice occurs on the 21st, t 5:00 A.M., EDT.

The **Moon** is full on June 4 at 9:02 A.M., EDT; reaches last quarter on June 12 at 1:36 A.M., EDT; is new on June 19 at 9:52 P.M., EDT; and reaches first quarter at 6:43 P.M., EDT on the 26th. On the 4th the full moon will be totally eclipsed when it passes through the earth's shadow. Al-though none of the eclipse will be visible east of Kansas, westerners will be able to see the eclipse in the predawn hours. The moon will enter the earth's umbral shadow at 4:11 A.M., Pacific Daylight Time, and totality will come just over an hour later.

Gail S. Cleere writes on popular astron-omy and is a founding member of the In-ternational Dark Sky Association, an or-ganization dedicated to preserving the night skies for astronomy.



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Bear Facts and Figures

by Paul Shepard

The interaction of bears and people, which goes back at least to Neanderthal times, has taken on fascinating new twists and turns in the last twenty years because of the research of field biologists. In selecting the wide-ranging essays for *Bears: Majestic Creatures of the Wild,* editor Ian Stirling has assembled much new information answering some old questions.

We have long known, for example, that tiny, newborn bears are less than 10 percent of the size they should be according to the usual weight ratios of mother to offspring in placental mammals. A newly posited explanation for this disproportionate tininess of ursine newborns is the physiological inability of a bear fetus to utilize the fatty acids available to it through the placenta. According to this theory, the fats must first be converted to glucose in milk, so the offspring must be born before it can take on significant weight.

According to a new scenario for the initial human occupation of North America, the huge short-faced bear, now extinct, may for centuries have blocked Asian migrants' way to the interior. As carnivorous as the polar bear, longer-legged, and therefore faster, this predator may have so threatened the earliest settlers that they initially migrated south along the Pacific Coast rather than east into the continent.

Perhaps the most striking characteristic of the world's northerly bears is their ability to stay in winter dens for as long as six months of the year. Since the bear does not eat or drink during hibernation, its life seems to swing between extremes of fasting and feasting. But what at first looks only like a fat bear going in and a thin bea coming out is far more complicated than appears. The bear is not completel inert—the whole sequence of gestatio and birth takes place in the den. But wha are the potential deleterious effects of suc immobility? Why don't the bear's bone lose calcium and become brittle? And wh isn't the animal poisoned by the accumula tion of its own uremic wastes from cellula breakdown? And why do bears suffer les general debilitation from obesity than hu

BEARS: MAJESTIC CREATURES OF TH WILD, edited by Ian Stirling. *Rodal Press, $40.00; 240 pp., illus.*

mans? These metabolic phenomena ar beginning to be studied and may have im portant implications for the medical treat ment of aged or immobile humans, as we as for space travel.

Bears have been described as "solitary, but new studies document instances of so cial behavior, such as brown bears tolerat ing one another at salmon rivers and pola bear females denning in communities. An other remarkable aspect of bears' behavio is their ability to navigate over long dis tances. Brown bears, if displaced by hu mans, are capable of returning severa hundred miles to their home range. Bu how do they construct their mental maps The answer seems to have several parts One is that they have extremely goo memories. A young American black bea that had followed its mother twenty mile to a feeding area, for instance, was know to return to the same place for three to fiv years afterward. Even more unexpected i evidence that bears sense the earth's mag netic field and can locate themselves in it gradients.

Recent study of the American blac bear has shown that much of its sense o



The giant panda
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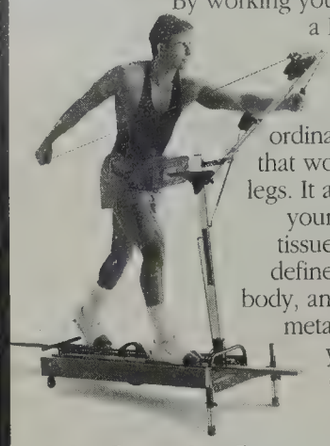
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place is defined by scent marking. What appeared in the past to be merely scratching is now understood as a communicative function in which bears, like many other large mammals, persistently signal their presence in their own home ranges.

Perhaps the most exciting new information has to do with the bears' adaptation to human presence. Like modern researchers among wild primates, students of the ursids are finding that bears, particularly black bears, which may initially threaten or flee from humans, can become so tolerant that people may move freely among them so long as they respect the female bear's concern for her young. This not only means that field studies can be undertaken at close range but also that bears and people can learn to live together without friction. Perhaps the hope for the survival of most bear species ultimately resides in this mutual toleration.

The threat bears pose to humans is much exaggerated. Most injuries to humans result from the animal's attraction to food, usually in picnic or camping situations. Once into a camper's larder, a bear is not easily driven off and may become a relentless bandit. But statistically, the chances of being injured by bears while on the trail are less than one in a million.

What a bear eats in the wild is now also better understood. New studies of black bear scats in different ranges and over different seasons have revealed an enormously varied diet but also one proportionately high in insects. Especially noteworthy is a population of black bears living in the barren grounds of northern Quebec and Labrador, occupying a niche probably left open by grizzlies killed off in the nineteenth century. In adapting to an open, cold country, the bears' size, home range, and hunting and denning habits have all changed. In the open tundra, for example, they eat much more than their southern neighbors do.

Compared with the American black and the circumpolar brown bears, the tropical bears are little known. The sun bear of Southeast Asia, the sloth bear of India and adjacent countries, and the spectacled bear of South America all have adaptations to life in, and at the edges of, tropical forests. To Western eyes, the sloth bear may be the most bizarre. Competition with wild cats, canids, and pigs has left it to shape a niche in which its dietary needs are met mainly by roots, tubers, ants, and termites. It is a prodigious digger, whose inner pair of upper incisor teeth have been sacrificed so that the mouth and snout could become specialized for blowing away the dirt around termites and lapping them up. Although other species of bears have rarely been seen carrying their young, the sloth bear does so regularly during the cub's first year, perhaps as a precaution against



Brown bears fishing for salmon
Jeff Foott; Auscape International

he danger of tigers and other predators.

The spectacled bear, the only bear in the Southern Hemisphere, has become a part of regional folklore, especially in Bolivia, because of its depredations against corn and cattle. New studies reveal, however, that it also eats dozens of species of bromeliads, thus giving hope that the bear could survive on foods that do not place it in conflict with humans. This bear builds high platforms in the tropical forest in which to eat and rest. The spectacled bear is widely bred in captivity, and of all captive bear species, its international breeding record—the "studbook"—represents the most detailed documentation of any bear's lineage and life history.

Several essays deal with the breeding and keeping of bears in zoos, in circuses, and as pets. Zoos are now endeavoring to make their "bear pits" more like natural habitats, in some cases even hiding the food in small quantities so that the animals forage somewhat as they do in the wild. Given the poor prospects for most bears in the twenty-first century, zoos may become the final keepers of the species if they become extinct in the wild.

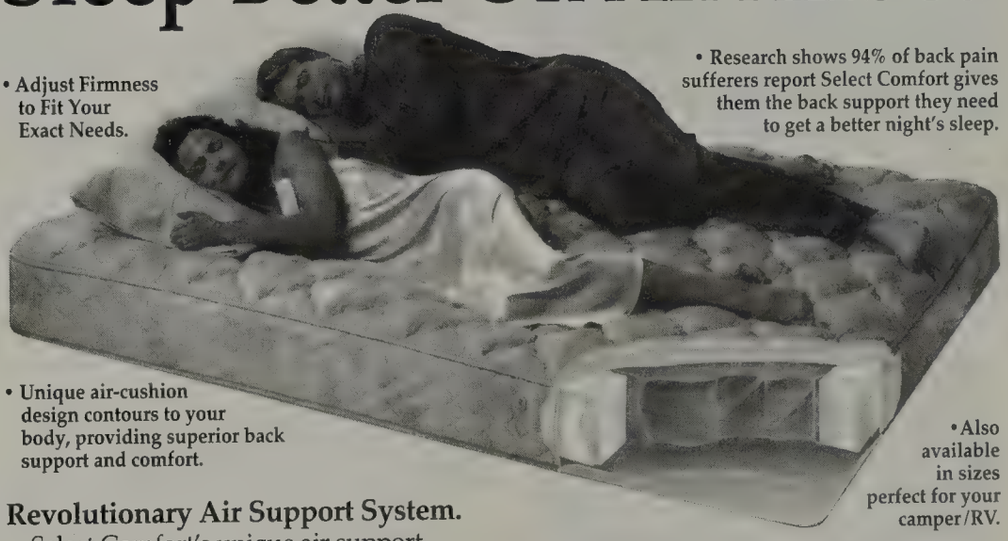
The bear's uncertain future in the face of growing human populations and the reduction of bear habitat is compounded by an increase in demand for gall bladders and other bear parts for use in folk medicine. This market is now commercialized on a world-wide scale. Modern poachers, armed with automatic weapons, are organized into a multinational trade in bear organs. This is seriously affecting the survival of the Asiatic black bear and the giant panda. Asian bears are being "farmed" for their bile, often in tiny cages in which they can hardly move.

Bears: Majestic Creatures of the Wild will undoubtedly become a standard reference for the general reader. The essays range from natural history, evolution, and fossil finds to field research and the mythology of man and bear, providing a succinct look at all aspects of the animal. Excellent drawings and diagrams are included, as well as scores of fair to excellent photographs. Written by more than thirty experts in bear research, the essays have some duplication and unevenness. The book, however, will not be read as a whole but used primarily as a richly diverse sourcebook.

Paul Shepard is Avery Professor of Natural Philosophy and Human Ecology at Pitzer College and Claremont Graduate School. His book The Sacred Paw: The Bear in Nature, Myth, and Literature *was published in 1985 by Viking Press.*



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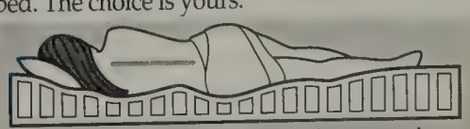
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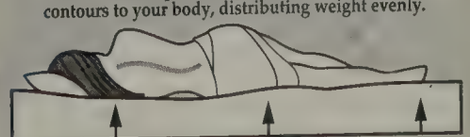
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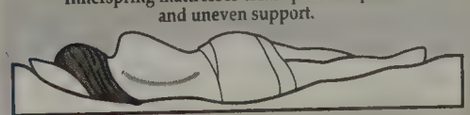
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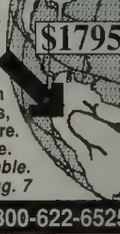
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At the American Museum of Natural History

Jurassic Dinosaurs

Inspired by the film *Jurassic Park,* a new exhibition in Gallery 3 of the American Museum of Natural History will take an in-depth look at dinosaur paleontology and genetic engineering. Opening Friday, June 11, "The Dinosaurs of Jurassic Park" will feature skeletons of a *Tyrannosaurus rex* and an *Alamosaurus,* each forty feet long and fourteen feet high. The *Jurassic Park* forest will be recreated, populated by dinosaur models from the film. The replicas will be accompanied by displays about dinosaur physiology and behavior, specimens of fossil insects and other organisms preserved in amber, and clips, props, and sets from the film. The exhibition will continue through Wednesday, September 15.

Bears, Real and Imagined

The real and imagined aspects of bears, and the many ways in which people relate to them, will be the subject of a Museum exhibition opening Friday, June 4, in Gallery 77. "Bears: Imagination and Reality" includes videos and dioramas of more than twenty-five grizzlies and black bears, showing the ways they face danger, feed, hibernate, care for their young, and die. The exhibition will run through the beginning of October.

On Saturday, June 26, a tour in sign language will begin at 1:45 P.M. in the second floor Rotunda. For information, call (212) 769-5566.

Marbling Paper Craft

Marbling is an ancient skill that dates back to eighth-century Japan. On Saturday, June 5, Steven Leipertz, a former Thorne Research Fellow in the Museum's Department of Herpetology and Ichthyology, will teach techniques of the craft, giving students an opportunity to marble their own paper. Limited to twenty adults, the workshop costs $65. Call (212) 769-5305 for more information.

All About Teddy

In conjunction with the Museum exhibition, "Bears: Imagination and Reality," the Hayden Planetarium will present a new Sky Show for children ages three to ten on Saturday, June 12, 19, and 26, at 11 A.M. "Teddy's Quest" tells the story of a teddy bear that was born in space and sets out on a quest to find a friend. (All kids are encouraged to bring their teddy bears.) Tickets are $5 for adults and $2.50 for children (members: $4 for adults and $2 for children). Call (212) 769-5900 for information about this show, as well as about "Bold Visions...Distant Shores," the Sky Show that explores Maya, Aztec, Inca, and Anasazi skylore, showing daily through June 28.



A painting by Brian Franczak of Albertosaurus, *a dinosaur featured in "The Dinosaurs of Jurassic Park."*

Quincentennial Perspectives

The final segment of the year-long quincentennial series will present a discussion of native cultures and their impact on Western society by Tonya Gonnella Frichner, a member of the Onondaga Nation, and president of the American Indian Law Alliance; a performance of contemporary Japanese dances by choreographer Saeko Ichinohe and her company; two African American films, *Family Across the Sea* about the roots of the Gullah people in Sierra Leone and *A Question of Color* about "color consciousness" in the black community; and masked African dances performed by CINQUE Folkloric Dance Theater.

On Saturdays and Sundays throughout June (except on Father's Day weekend, June 19 and 20), free demonstrations and performances in the Leonhardt People Center will include contemporary Japanese dances by choreographer-dancer Dawn Saito; discussion of violence against Asian Americans; a play by the Kabayan Players, a Filipino troupe; and West African rhythms and Sioux melodies by members of the group Mamma Tongue. For a complete schedule, call (212) 769-5315.

Remembering Little Bighorn

Although there were no survivors of Gen. George Armstrong Custer's Seventh Cavalry after the battle of Little Bighorn on June 25, 1876, hundreds of Lakota and Cheyenne Indians lived to tell their stories. Paul Stekler, an independent film maker, will talk about these accounts and show his film, *Last Stand at Little Bighorn,* on Friday, June 25, at 7:00 P.M. in the Kaufmann Theater. Tickets are $10 ($7 for members). Call (212) 769-5606 for information.

AVEL PHOTOGRAPHY IN
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Photographer Willa Zakin will lead a
oup of twenty-five people on a one-day
otographic field trip to New Hope, in
cks County, Pennsylvania. The trip, on
turday, June 5, from 9:00 A.M. to 6:30
. costs $70. For more detailed informa-
n, call (212) 769-5310.

SCI-FI CLASSIC
The 1979 blockbuster *Alien* will be the
ne presentation of the science-fiction
n series. Starring Sigourney Weaver, the
n is an account of a monstrous life force
t invades the spaceship *Nostromo*. In a
rty-minute preview, Brian Sullivan, the
yden Planetarium's production de-
ner, will talk about the special effects
t have contributed to making this a clas-
. *Alien* will be shown in the Kaufmann
eater on Saturday, June 5, at 3:00 P.M.
ckets are $7 ($4 for members). Call
12) 769-5606 for information.

OVENTURES IN THE FIELD
Sidney Horenstein, coordinator of the
useum's environmental programs, will
d a series of boat cruises in the New
rk area. On Tuesday, June 1, from 6:00
. to 9:00 P.M., an evening geology ex-
rsion around Manhattan will survey the
igins of the Palisades and other land-
ape features. Tickets are $25 ($22 for
embers). On a three-hour tour, Tuesday,
ne 8, from 6:00 to 9:00 P.M., passengers
ll learn how the bays and waterways of
etropolitan New York were formed and
serve the surprisingly abundant birdlife.
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dson estuary and Upper Bay, Gowanus
y, the Narrows, Gravesend Bay, and
ckaway Inlet will be featured in a day
p on Saturday, June 5, from 11:00 A.M.
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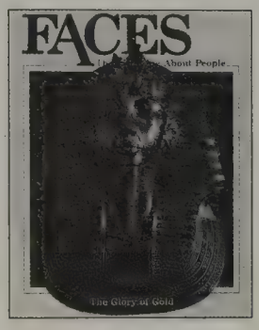
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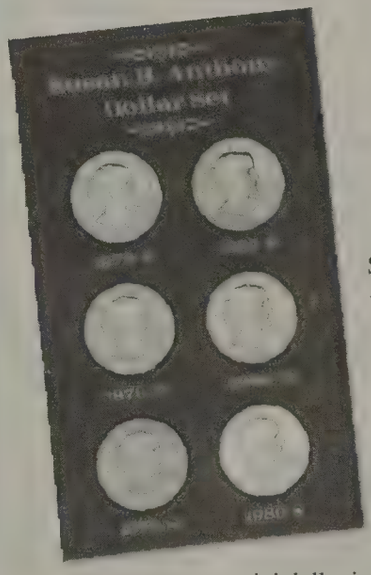
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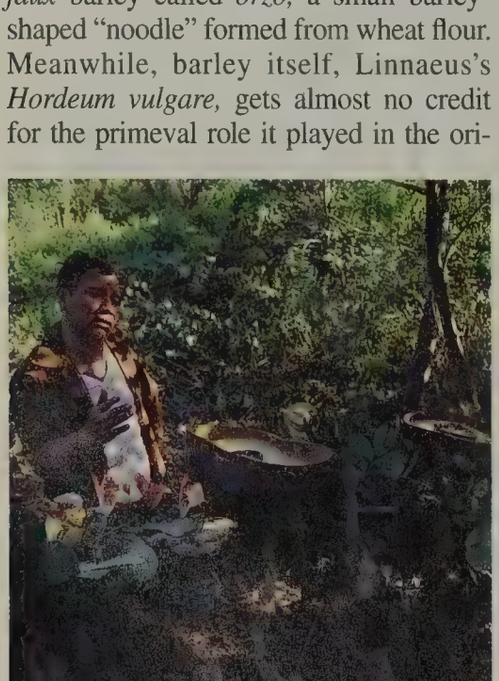
Barley's Ghost

All but forgotten as a staple food, the grain now haunts the realm of drink

by Raymond Sokolov

Anyone looking for a symbol of the submersion of traditional values in a trash-filled sea of modern life could do worse than pick on barley. This wholesome grain lurks in the background of most cuisines, a wallflower no one asks to dance much any more. Yes, there is Scotch broth and there is mushroom and barley soup. In a few advanced restaurants and cookbooks, barley crops up, so to speak, as a novelty or a stand-in for better-known grains: barley risotto is the leading example.

But mostly, it works the other way around. Italians eat a pasta that is really a *faux* barley called *orzo,* a small barley-shaped "noodle" formed from wheat flour. Meanwhile, barley itself, Linnaeus's *Hordeum vulgare,* gets almost no credit for the primeval role it played in the origins of settled human life and civilization.



Atole *ready to be served at a traditional crop-blessing ceremony in the Yucatan Peninsula*
Kenneth Garrett

Barley can still be seen in its ancient glory as the staple grain of a culture, but only in certain remote places, like the Ecuadorian village that Mary Jo Weismantel described so eloquently in *Food, Gender, and Poverty in the Ecuadorian Andes* (University of Pennsylvania Press, 1989). Or in Tibet. In such bracing climates, where the hard currency necessary to import wheat or rice is not available, barley holds sway. But almost everywhere else, more versatile starch sources have swept the field. Barley's greatest advantage used to be that it could grow where more delicate grains couldn't make it. Oats and buckwheat and rye also filled demanding agronomic niches in the old days.

Cheap modern transportation has all but eliminated the need for these hardy old grasses. North America can supply wheat to most of the world. Rice long ago displaced millet in China. Scotland is not the oat ghetto it once was, so Scots can have airy white wheat bread like the rest of the world instead of flat, leaden bannocks.

This process of gramineous dethronement has especially humbled barley, leaving only a few crucial vestiges behind. Of all major industrial countries, Korea is probably the last to preserve an important visible role for barley. Koreans drink it.

At the end of the lunch hour in the upstairs dining room of Kang Suh, at 1250 Broadway in Manhattan's Herald Square, you can see Korean businessmen winding up their meal with little blue bottles of *soju,* a bluish, 20 to 25 percent alcoholic distillation of barley (or rye or sweet potatoes, but not rice). At the even more completely un-Americanized restaurant across the street, they brought me *poricha* one winter night. Brewed from toasted barley, this decoction is a constant feature of tra ditional Korean life. The taste reminde me at first of hot porridge. This turned ou to be a creative misunderstanding that le me to consider the significance of a whol spectrum of lost or depreciated grai dishes. Porridge is a poor word to describ the category of dishes I have in mind, bu it is where we almost have to start, sinc porridge—hot, thick breakfast cereal—the most familiar example of all those we boiled gruels and grits and groats that onc fed our ancestors or formed the core o their alimentary universe.

If the origin of agriculture is the abilit to plant edible, harvestable grass seed the origin of cooking is the ability to mak those seeds palatable. After toasting o milling, the next—and really the most fun damental—step was to moisten the grai product, in whatever form it came to th kitchen. Before anyone learned to mak bread or cake or noodles, someone discov ered how to make mush with cold and the with hot water. Oatmeal is a link with th most primitive days of subsistence i northern Europe. Barley gruel takes u back to the dawn of all cuisine.

The form in which most of us now ex perience a survival of prehistoric barle cookery is when we drink beer. Beer star with sprouted barley. The process, calle malting, occurs when moistened barle grains are allowed to germinate and, inc dentally, to convert inborn starches into fermentable sugar called maltose. N doubt, the primordial malt makers in a the many cultures that fell into wettin barley and letting nature take its cours kept at it because sprouted barley was ed ible as such and didn't have to be hulled o cracked or milled. From there it was but step (actually more than one) to exploitin

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the natural fermentation inherent in malting, either to make an intoxicating drink (beer) that got its punch from the alcoholic byproduct of malting's yeast fermentation or to produce a solid food (bread) that got an appealing lift from the same process's release of carbon dioxide gas.

Scholars such as Solomon Katz, of the University of Pennsylvania, now debate which came first, bread or beer. But the ancestor of both was wet barley (or wheat and all the other grains). And even without waiting for those grains to sprout or ferment, ancient peoples could make them into beverages, porridges, gruels, batters, and doughs—depending on how dilute the mixture of grain and water was.

In the modern world, where industrially manufactured flours and pastas are commonplace and cheap, the drier end of the moistened grain spectrum predominates. The dry products store far better, and we can consume more grain more efficiently if it is boiled in barely the amount of water necessary to cook it (steamed rice, oatmeal), drained completely (pasta) or barely moistened (bread, cake). We no longer need to thin out our grain allotment with water, so the grain drinks that once invigorated Europe have either disappeared or changed their nature almost completely, leaving behind a few ghost names, many of them whispering barley to those who care to listen.

I am not talking here about the myriad beers made from every fermentable grain in the universe in every country. I am not referring to Turkish *boza* (fermented from bulgur wheat) or premasticated, corn-based chicha from the forests of South America or African millet beer or any of the thousands and thousands of barley-based manufactured brews, from Korean Obi to Jamaican Red Stripe. I mean plain old boiled-grain decoctions such as Mexican/Aztec corn *atoles* and chocolate-flavored, corn-based *champurrados*.

In North America today, the only important survival among the various grain teas of yore is an oat-based, powder-form beverage principally consumed by Spanish speakers. In Spain itself, the most venerable of all grain drinks, barley tea, or barley water, survives only as the name of a popular beverage called *horchata*. The word derives from the Latin *hordeum*, meaning "barley," as do its Italian, French, and English equivalents (respectively, *orzata, orgeat,* and *ozyat*).

There is no longer any barley water tradition in the English-speaking world, but there once was and, as C. Anne Wilson explains in *Food and Drink in Britain* (Barnes and Noble, 1974), this heritage exemplifies the history of the drink all over early modern Europe:

It had a long history as an invalid beverage. In the sixth century A.D. Anthimus had recommended a thin drink made of barley with pure warm water as beneficial for fever patients. The later medieval version in France had the name tisane (from the Greek *ptisar* for barley water), was sweetened with sug and seasoned with licorice and sometime also figs. Adapted for English use it mo often comprised barley boiled in water wi licorice, herbs and raisins. It was still licorice-flavored drink in the first part of th seventeenth century, but soon afterwar was brought up to date by the substitution lemon juice for licorice.

Five Grain Drinks

Poricha

(Korean barley tea, adapted from *Flavours of Korea,* by Marc and Kim Millon, London: André Deutsch, 1991)

- *4 tablespoons roasted barley (available from Korean grocers)*
- *6 cups water*

1. Soak barley in water for 30 minutes.
2. Bring mixture to a boil and simmer slowly for an hour.
3. Pour through a sieve into a teapot. Serve hot or warm or, in summer, chilled with honey.

Yield: 8 servings

Boza

(Bulgur wheat and rice drink, adapted from Nevin Halici's *Turkish Cookbook,* London: Dorling Kindersley, 1989)

- *6 ounces bulgur*
- *2 tablespoons rice*
- *1½ cups sugar*
- *½ teaspoon dry active yeast*
- *1 teaspoon ground cinnamon*

1. Combine the bulgur and rice with 3 quarts of water. Bring to a boil, reduce heat, and simmer, covered, for about 1½ hours, until the mixture thickens.
2. Sieve and put the purée back in the pot. Stir in sugar. Bring to a boil and stir for 2 minutes to dissolve sugar. Let cool until lukewarm.
3. Activate the yeast by stirring it together with a little of the cooked purée. When it begins to rise, stir into the *boza* mixture, cover, and leave to ferment in a warm place for about 8 hours—until the surface bubbles. The taste is bittersweet.
4. Pour into large glasses. Sprinkle with cinnamon. In Turkey this is served with roasted chickpeas (*lebleb*).

Yield: 8 servings

Agua de Arroz

(Spanish rice tea, from Lourdes March's *El Libro de la Paella y de los Arroces,* Madrid: Alianza, 1985).

- *½ cup medium-grain rice (available in Hispanic markets)*
- *1 lemon peel or 1 teaspoon aniseeds*
- *1 cup sugar*

1. Boil the rice with 1 quart water, over low heat, for 30 to 40 minutes, until the mixture thickens slightly.
2. Strain, add the lemon peel or aniseeds and the sugar. Stir until the sugar dissolves.
3. Chill. Strain again and serve.

Yield: 4 servings

Atole Blanco

(Mexican Corn Tea)

- *2½ cups* masa harina *(Mexican hominy cornmeal)*
- *1 1-inch stick cinnamon, preferably true Ceylon cinnamon, sold as* canela *in Hispanic markets*
- *¾ cups sugar*

1. Stir the *masa* into 5 cups of water until it "dissolves" into a smooth mixture. Sieve, add the cinnamon.
2. Simmer over low heat until the mixture thickens. Add the sugar, stir until it dissolves, and continue cooking until the mixture thickens a bit more.

Yield: 6 servings

Horchata de Arroz

(Spanish rice drink, adapted from Lourdes March)

- *1 cup medium-grain rice*
- *1 lemon peel*
- *1¼ cup sugar*

1. Soak the rice with the lemon peel in 4 cups cold water to cover for 24 hours.
2. Remove lemon peel, purée in food mill or blender to produce a smooth mixture. Strain, adding two glasses of water, little by little. Stir in the sugar until it dissolves and chill.

Yield: 4 servings

Another variant of barley water in rance, called *orgemonde,* was flavored ith ground almonds. This too reached ngland during the seventeenth century, its ame softening to "orgeat" or "ozyat." Subquently, the barley dropped out and Engsh ozyat was made from ground almonds d sugar with orangeflower water or the ice of citrus fruits boiled with spring ater. It was a cold drink similar to lemonde. Milk ozyat was boiled, spiced milk, ooled and mixed with ground almonds; nd special ozyat glasses with handles were esigned to serve it in.

Italian *orzata* and French *orgeat* today re also almond-flavored sweet drinks, ith barley only an etymological feature f their names. Spanish *horchata* is a more omplicated case. In one form, rice has upplanted barley. In another one, the ost popular, it includes ground chufa, or ger nut. Penelope Casas states unequivoally in *The Foods and Wines of Spain* Knopf, 1982) that this *chufa horchata* is f Arabic origin. This makes sense (as oes an Arab origin for the rice *horchata,* ince the Moors also introduced rice to pain—and Europe) because the tiger nut" (*Cyperus esculentus*) is the underground tuber or corm of a plant (a.k.a. arth almond, earth nut, rush nut, and Zulu ut) whose remains have been found in gyptian tombs of the third millennium .C. And Theophrastus mentioned it as omething Egyptians harvested and ooked in barley juice.

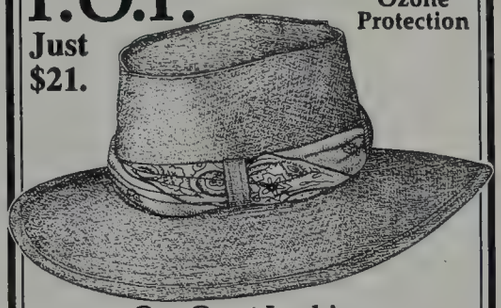
Today the chufa is grown commercially round Valencia, but it seems likely that it raveled from an ancestral center in Egypt o Spain where it now provides pleasure to millions. But did the import of chufa, with ts ancient connection with barley, start Europe's craze for barley water? Or did chufa, arriving in the low Middle Ages, meet an already entrenched custom of consuming thinned-out barley purée? The second scenario strikes me as more likely and leaves open a more logical route for the substitution of imported rice for homegrown barley in *horchata.*

Today, those old-time barley waters have all been superseded by zippier potations. In any self-respecting French cafe, a tisane is an herbal tea. In New York's Little Italy, almond *orzata* is a staple—and domestically produced. In Mexico City, everyone knows that *horchata* is made, as in Spain, from rice—except when it is prepared with melon seeds.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.

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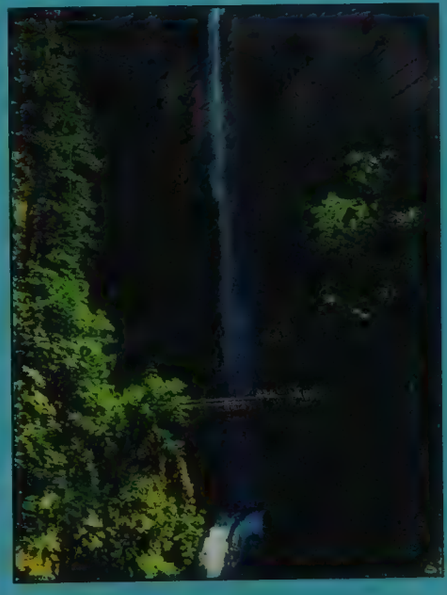
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Storm-tossed Survivor

The female leopard waited in a tree, monitoring the approach of a group of impala. Then she descended and began to stalk them. Suddenly the rain came in torrents. Her prey fled, and the leopard accepted a drenching.

Accustomed to being watched by safari guides and visitors to Kenya's Masai Mara Game Reserve, this six-year-old cat was born in a crevice in Leopard Gorge, about three miles from the spot where the photograph was taken. There she gave birth to cubs of her own, but her first two litters did not survive—probably victims of lions, hyenas, or baboons in the area.

The most adaptable of the big cats, leopards are found from tropical rain forest to arid savanna, from mountains to the lowland plains. They hunt mammals and birds, commonly taking fairly large ungulates in Africa. In Asian forests, they feed on monkeys and even mice and arthropods if necessary. Nocturnal where they are hunted, and usually solitary, leopards are adept at climbing trees and defer to lions and tigers on matters of food and territory. Perhaps their ability to keep out of sight and to avoid unnecessary confrontations has protected them from being exterminated by humans. Long a favored prey of sport hunters and prized by the fur trade, leopards have suffered major declines in numbers. Nonetheless, they still inhabit a huge range that stretches from Africa through the Near East to eastern Asia and as far south as Indonesia.

Erwin and Peggy Bauer spent six weeks photographing this female (which finally managed to raise a cub), and were impressed with her resourcefulness. Erwin Bauer calls her "a supersurvivor, symbolic of the species and its problems. By one means or another, the leopard is hanging on almost everywhere in its range."—*R. M.*

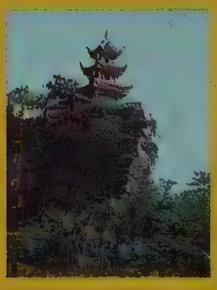
Photograph by Erwin and Peggy Bauer



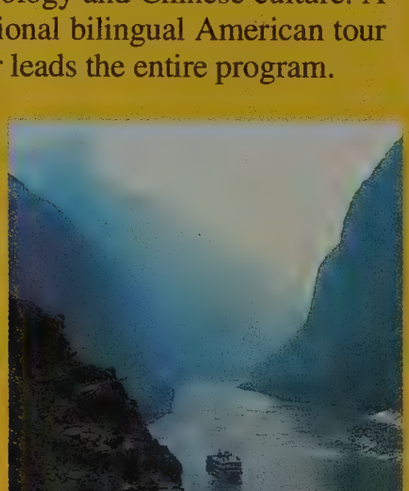


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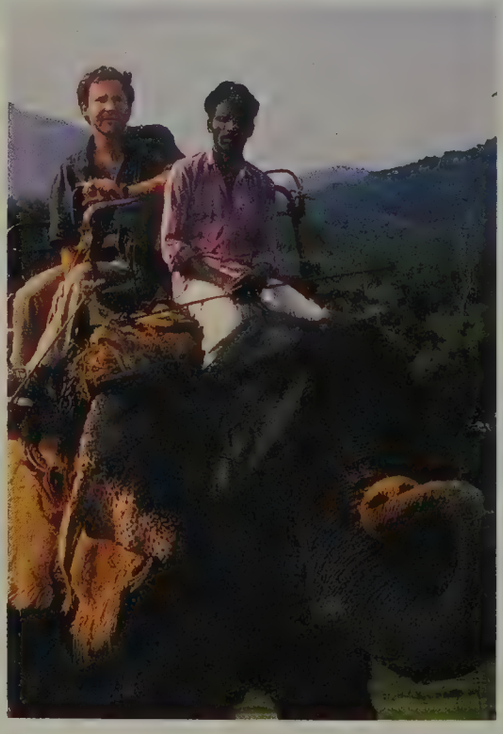


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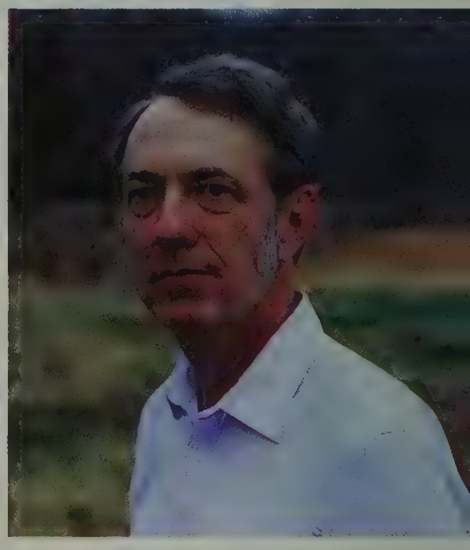
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AUTHORS

While studying architecture in India for a year, **Peter Engel** (page 48) was attracted to the astronomical observatories of Jai Singh. Although the strange forms of the observatory buildings are famous worldwide and draw many visitors, few Westerners have had the opportunity to learn the details of how they were used and why they were constructed. With the assistance of the chief astronomer-astrologer and others at the observatory



in Jaipur, Engel delved into the history of the structures and gained an appreciation of the maharajah who built them. Engel's interest in the history of astronomy stems from his undergraduate work at Harvard University, where he studied the history and philosophy of science. He received his graduate degree in architecture from Columbia University in 1987. Engel has traveled extensively throughout Asia, focusing his studies on the challenge of housing the increasing number of urban homeless. He is an architectural designer and urban planner living in Oakland, California, and is currently writing a book on traditional Indian architecture. Engel is also an expert practitioner of origami and has written a book on the subject.



Matt Cartmill (page 6) first saw *Ban* in 1982 while working on an article abo hominid evolution for *Natural Histo* ("Four Legs Good, Two Legs Bad," N vember 1983). In the movie's portrayal man as a nemesis of other creatures, "recognized Raymond Dart's killer a loose in the magic forest of nature." Wh he realized that the movie had been ma at least a decade before Dart publicized view of *Australopithecus* as a vicious to wielding predator, Cartmill began to tra the history of the subject.

Originally from Los Angeles, Cartm has degrees in anthropology from Pomo College and the University of Chicago. professor of anatomy and biological a thropology at Duke University Medic Center, where he has taught for almo twenty-five years, he also edits, with h wife, Kaye Brown, *The American Journ of Physical Anthropology* and still fin time to continue investigating human pe ceptions about the animal world. For fu he rides horses, sings shape-note hym with a Sacred Harp group, and collec Northwest Coast Indian art.

He recommends reading Russe Banks's "Bambi," in *The Movie Th Changed My Life*, edited by David Rose berg (New York: Viking Penguin, 199 and *Walt Disney's Bambi: The Story of t Film*, by Ollie Johnston and Fra Thomas (New York: Stewart, Tabori, a Chang, 1990).

Torben Larsen (page 30) dons his ntileech socks, custom-made in the Port Blair bazaar in the Andaman Islands. After a childhood in Greece and India, where he developed an interest in natural history, Larsen attended the University of Copenhagen in his native Denmark and graduated as an economist in 1970. He has since worked on development projects in many parts of the world, but in 1986 became a free-lancer in order to have more time for butterfly research. He is the author of the standard reference works on the butterflies of Lebanon, Jordan, Egypt, Kenya, Botswana, and Arabia and has just embarked on a five-year study of the butterflies of West Africa. Butterfly migration remains one of his favorite topics: "I saw my first large-scale butterfly migration as a kid in South India," Larsen notes, "and I've been hooked ever since: The sight of millions, or even billions, of butterflies flying steadfastly in the same direction for days or weeks on end is just as awesome to me today as it was then."



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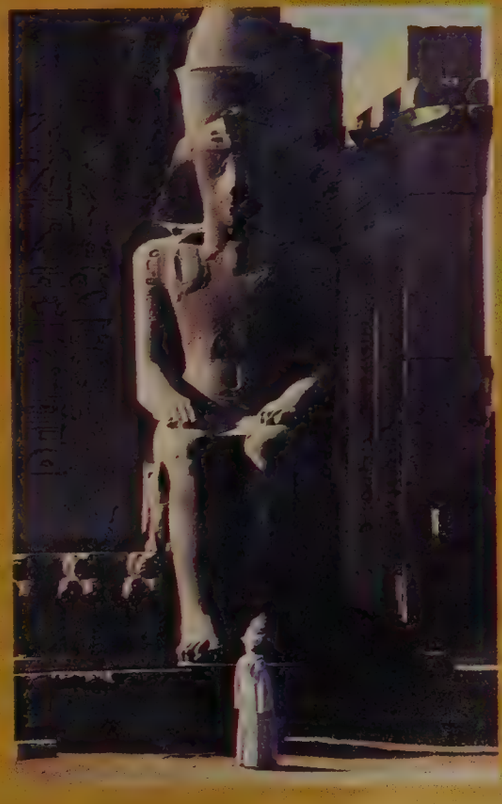
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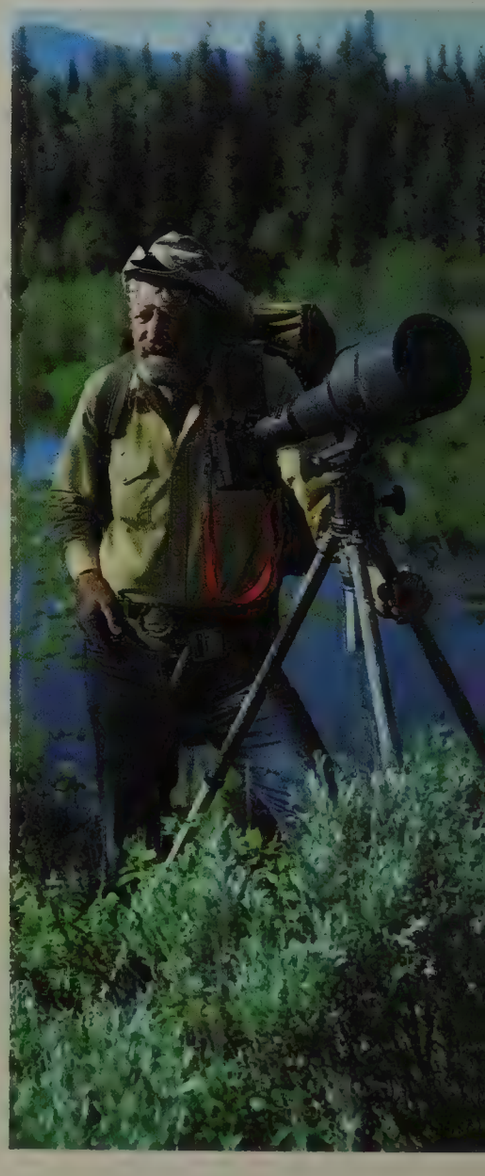


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Tim Flannery's zoological realm—all of the southwest Pacific, including Australia and Indonesia—is like no other place on earth (page 40). Inhabited today by quolls, Tasmanian devils, and Komodo dragons, the region was once home to an equally unusual array of prehistoric animals. Flannery's study of the ways in which a land's resources shape its fauna led to his hypothesis on why carnivores in Meganesia differ so greatly from those of other continents. He first published these ideas in *Australian Natural History*, the magazine of the Australian Museum, in Sydney, where he is a senior research scientist and head of the mammal section. Flannery, who received his doctorate in zoology from the University of New South Wales, continues to study the fauna of the southwest Pacific and to promote the conservation of endangered Australian mammals. His leisure-time activities, bushwhacking and fishing, also serve him well on regular scientific excursions to places such as Papua New Guinea. For further information, readers can refer to Flannery's article, "Who Killed Kirlilpi?" *Australian Natural History* (vol. 23, p. 234). *Kadimakara: Extinct Vertebrates of Australia,* edited by P. V. Rich and G. F. Van Tets, illustrated by Frank Knight (Princeton: Princeton University Press, 1991) deals with prehistoric fauna, from fishes t mammals. More of artist Peter Schouten work appears in *Prehistoric Animals Australia* (The Australian Museum, 198 and *The Antipodean Ark* (Argus an Robertsons, 1987).





Erwin and Peggy Bauer (page 76), midwesterners by birth, now base themselves in Livingston, Montana, but spend most of the year traveling the world in search of new and better opportunities to photograph (and write about) wildlife. They work so closely together that they usually do not know who took which shot. In the case of the leopard in the rain, however, they know that the honors go to Peggy; only her camera still had film in it when they headed back to camp in a downpour. Their relaxation takes the form of wilderness river running, and last summer the couple joined an expedition that went down the Alsek-Tatsenshini rivers, starting in the Yukon and ending in Dry Bay, Alaska. Peggy has made a collection of the myriad animal skulls found in her travels; represented among the larger specimens are a sea lion, a grizzly bear, and *Homo sapiens.* She took this month's "Natural Moment" with a Canon EOS1, 400mm r/2.8 autofocus lens.

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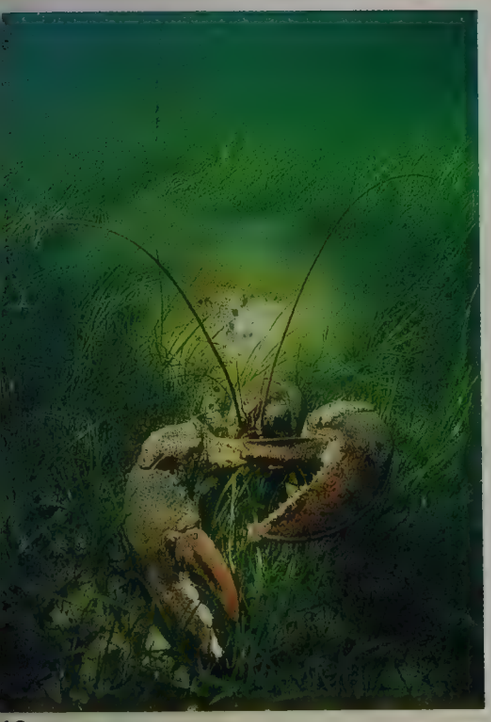
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COVER: *Are there left-handed animals, as this black-tailed prairie dog in North Dakota seems to be? While the anwer is not certain, a study of trilobites shows that some left-handers have been around a long time. Story on page 32. Photograph by Erwin and Peggy Bauer; Bruce Coleman, Inc.*

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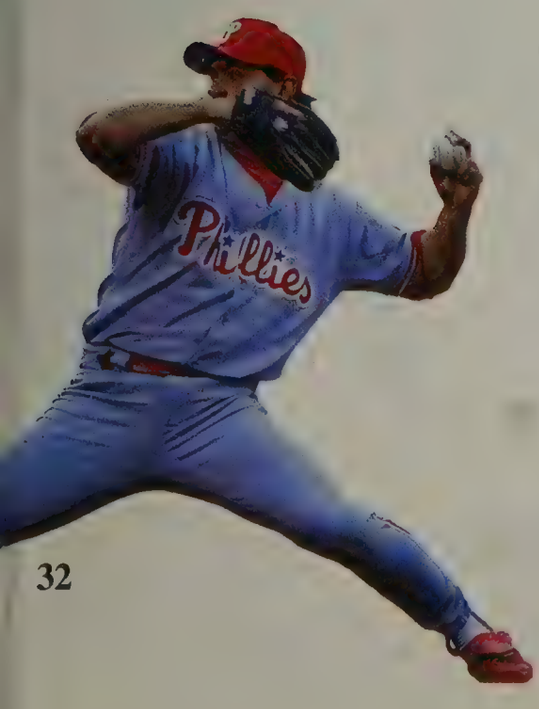
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LETTERS

ANCIENT FRACTURES

I enjoyed Geoffrey Pope's article "Ancient Asia's Cutting Edge" (May 1993), but I have one bone to pick with him. He describes "a massive horse butchery site, where the lower jaws of the animals were broken in order to retrieve an ancient delicacy, horse tongue."

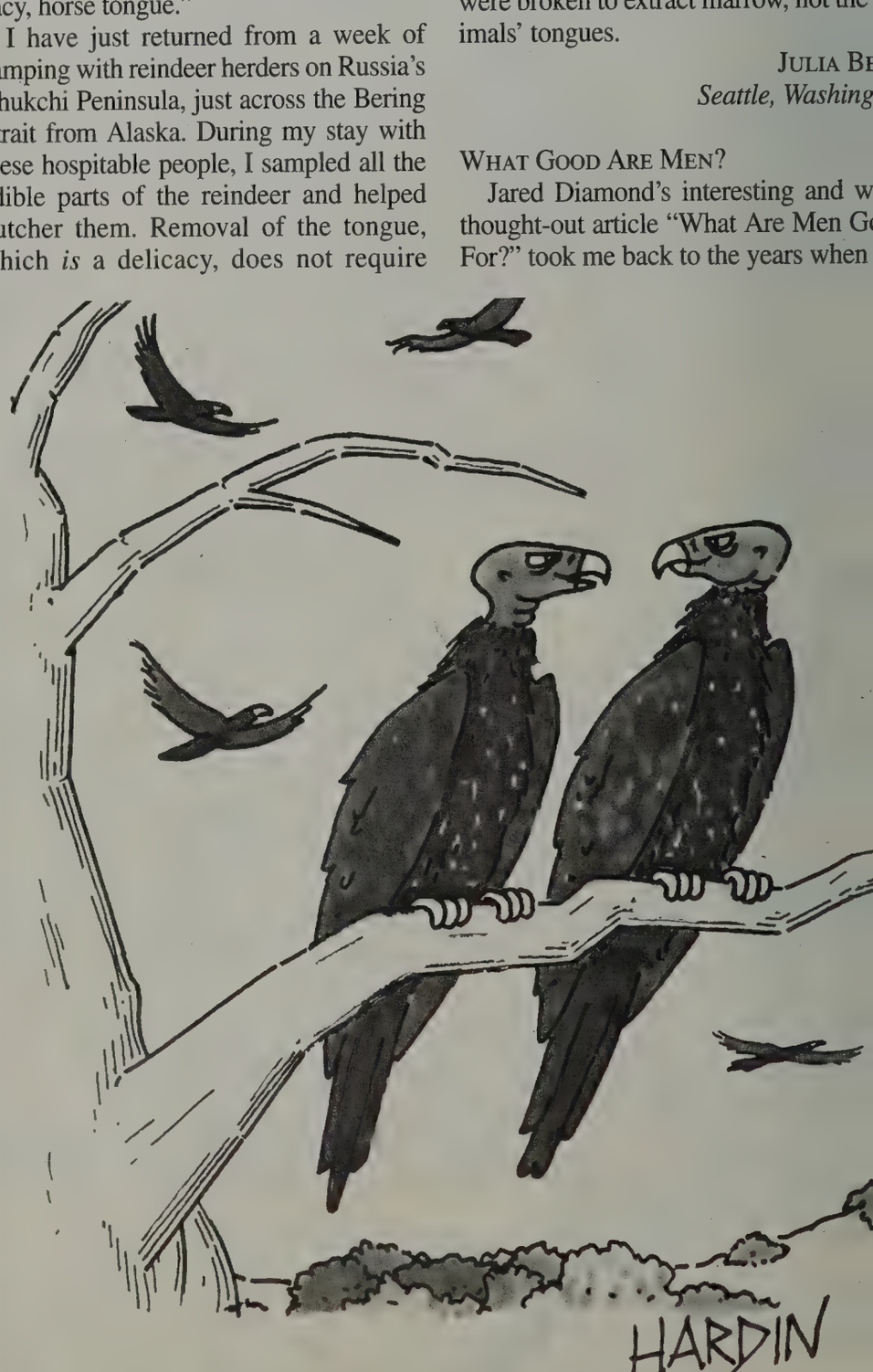
I have just returned from a week of camping with reindeer herders on Russia's Chukchi Peninsula, just across the Bering Strait from Alaska. During my stay with these hospitable people, I sampled all the edible parts of the reindeer and helped butcher them. Removal of the tongue, which *is* a delicacy, does not require breaking the lower jaw. Rather, the m
dible is broken to retrieve the marrow-
special treat offered to me on two oc
sions. To extract the marrow, the Chuk
either shattered a mandible on a rock
fractured it with a hatchet.

I suspect that at Xujiayao, lower ja
were broken to extract marrow, not the
imals' tongues.

JULIA BE
Seattle, Washing

WHAT GOOD ARE MEN?

Jared Diamond's interesting and w
thought-out article "What Are Men Ge
For?" took me back to the years when



"I like the ambience of I-75, but the turnpike has better food."



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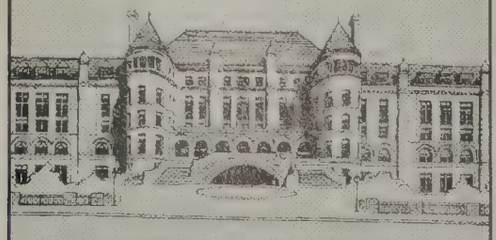
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law practice centered on representing victims of spouse abuse. I either represented or consulted with more than a thousand women with legal problems relating to violence inflicted on them by their husbands or boyfriends.

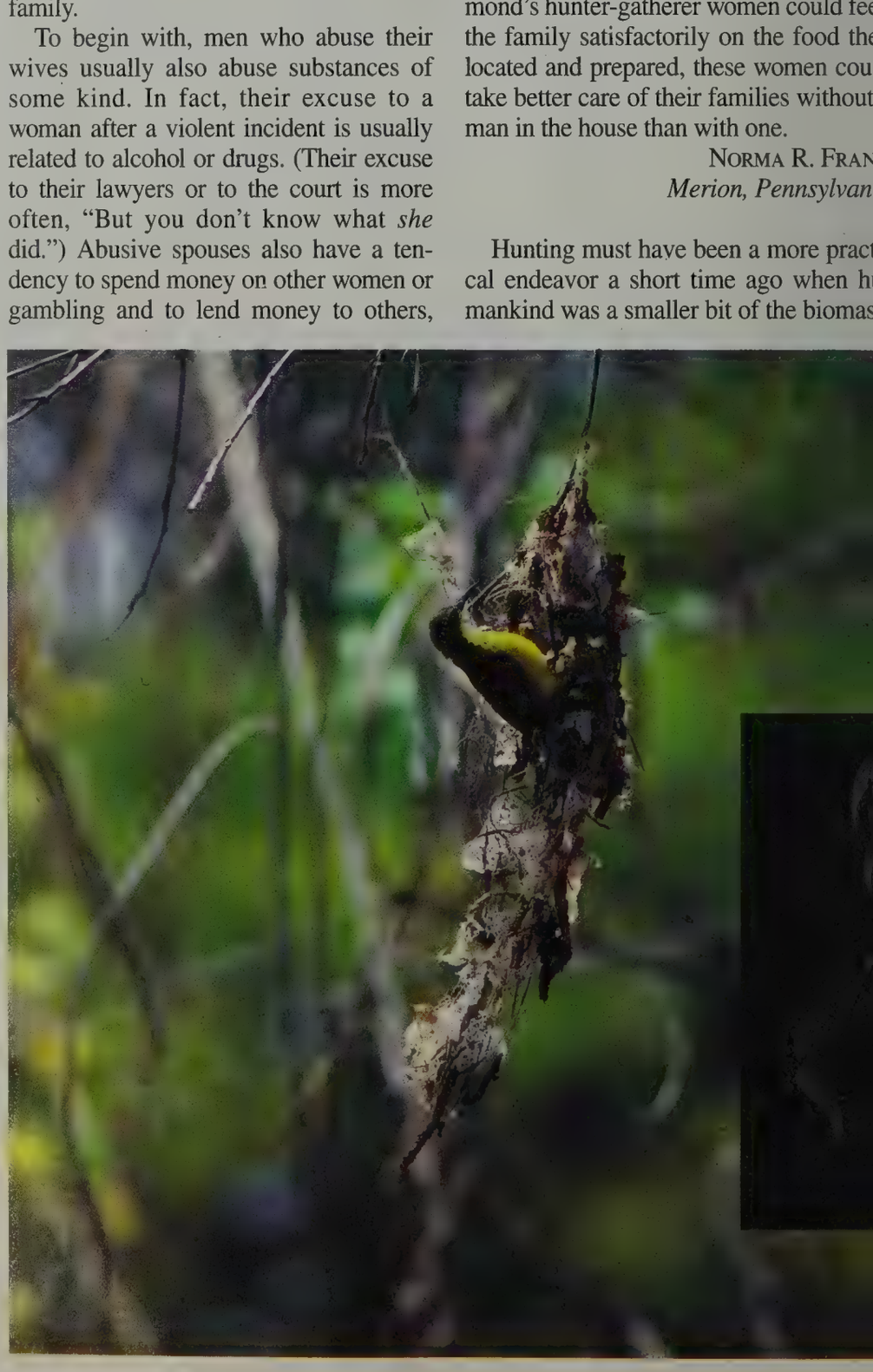
Very often the woman would tell me that she could not separate from her husband for economic reasons. She would point out that his income was much greater than hers. I would respond by saying that we should review her expenses and see if that was true. In more than 90 percent of all cases, we found that although the man's income was significantly higher than the woman's, his expenses were greater than the amount of money he brought into the family.

To begin with, men who abuse their wives usually also abuse substances of some kind. In fact, their excuse to a woman after a violent incident is usually related to alcohol or drugs. (Their excuse to their lawyers or to the court is more often, "But you don't know what *she* did.") Abusive spouses also have a tendency to spend money on other women or gambling and to lend money to others, often to women they barely know. Finall compared with nonabusive spouses, abu sive spouses spend a disproportiona amount of their income on gear for them selves and their hobbies. This cuts signif cantly into the amount of money that the allocate to family needs. Diamond's de scription of men who hunt and give th game to women other than their wives r minded me of the behavior of abusiv spouses.

At the end of our financial analysis, th abused spouse usually found that her hu band was spending more than he wa bringing into the family, taking into co sideration what she spent on him for clot ing, food, and incidentals. Just as Di mond's hunter-gatherer women could fee the family satisfactorily on the food the located and prepared, these women cou take better care of their families without man in the house than with one.

NORMA R. FRAN
Merion, Pennsylvan

Hunting must have been a more pract cal endeavor a short time ago when hu mankind was a smaller bit of the biomas



dditionally, those skills and talents eeded for defense are nurtured by hunt-g: use of weapons, strategy, stealth, ag-ression, reconnaissance, and physical owess. The warrior virtues are essential survival, especially when resources are arce. The reproductive advantage of a showoff' male is conferred by the prefer-nces of the tribal women, which derive om their own genetic self-interest.

JOHN L. SCHENKEL
Scotia, New York

ILK AND DISORIENTED NESTS

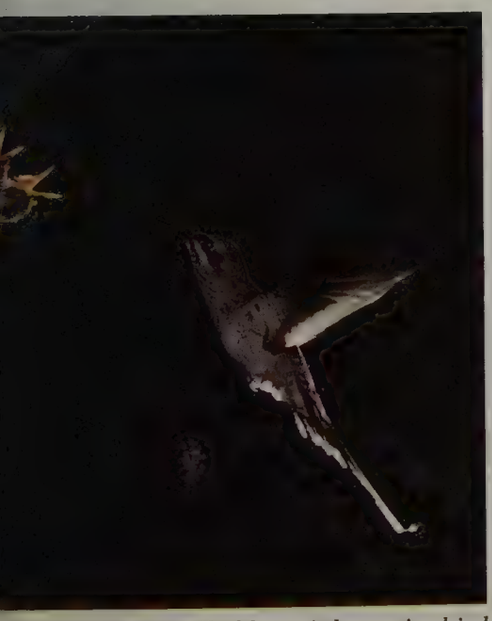
In addition to strength and adhesive-ess, the stretchability of silk appears to be mportant in hummingbird nests ("Sec-ndhand Silk," May 1993). The nest cups ypically expand and often flatten as the rowing birds fill and then overflow them.

PAT GIGAS
San Marino, California

It was amazing to see what birds can do ith "Secondhand Silk." But defy grav-y? Some birds can *hang* their nests be-ause of the tensile strength of spider silk nd its utility in anchoring materials. This as not apparent in two of the pictures (the ellow-breasted sunbird and the long-ailed hermit hummingbird), which were nfortunately printed sideways.

BERND HEINRICH
University of Vermont
Burlington, Vermont

We thank those who pointed out our error, nd we apologize to the authors, the pho-ographers, and the readers. The pictures re reprinted correctly on this page.—*Eds.*



Long-tailed hermit hummingbird
Gunter Ziesler; Peter Arnold

ow-breasted sunbird
Atkinson; Oxford Scientific Films

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Submarine Beetles

When the tide comes in, they batten down the hatches

by Tristram Wyatt

One summer evening, I watched the tide as it flowed gently up the creek like a river in reverse, creeping slowly over the salt-marsh shore in Norfolk, England. Out of the corner of my eye I saw a flash of red. A small, shiny black-and-red beetle had run in and out of its burrow; then, moments later, it disappeared under the rising water. I had not expected to see a land beetle here, but remembered reading about a species that lives in intertidal zones. Was this the salt-marsh beetle? Yes, it was *Bledius spectabilis,* a staphylinid beetle about half an inch long. During the next low tide, I discovered hundreds of burrows among the *Salicornia*—stubby little plants with water-swollen stems—that follow a contour around the salt-marsh creeks. Each burrow had a characteristic little heap of tailings above its entrance. The beetle I saw had emerged to scrape algae from around the burrow's entrance; then it carried the morsels down below, to be stored and later eaten in safety.

The intertidal zone is a difficult habitat that few animals can exploit. It is between land and sea, and a creature adapted to one is often poorly adapted to the other. Most intertidal animals are essentially marine species, such as crabs, that colonize the land. Their major risk is drying out on a sandy beach or rocky shore. By contrast, muddy salt-marsh shores in northern Europe, with their wetland acres of mud and quiet creeks, can support such land animals as spiders and mites that have moved into intertidal zones. Some have evolved great tolerance for seawater and can pump excess salt from their bodies; others simply develop behaviors to avoid getting drenched. Insects' cuticles are already impermeable to prevent water loss on land, but their main challenge has been to adjust to the tides. Those that have adapted to life in this difficult environment can exploit a rich habitat. The only serious competitor of *Bledius* is the gray mullet, a fish that comes in at high tide and also feeds on shoreline algae, leaving its toothmarks in the mud.

Colonies of salt-marsh beetles may occupy hundreds of square yards in the intertidal zone, with densities of a thousand adults per square yard. Colony perimeters are abrupt; no beetles dig burrows outside its boundaries. Sometimes the muddy beach is covered with beetles; on a given shore, they can number in the millions.

How does this land beetle survive the twice daily tides without any special bodily adaptations? It lacks, for example, snorkel tubes that might allow it to breathe under water. The answer lies in its behavior: the salt-marsh beetle builds and maintains a snug, watertight burrow. And the females are good parents, protecting their eggs and larvae from predators as well as from the tides.

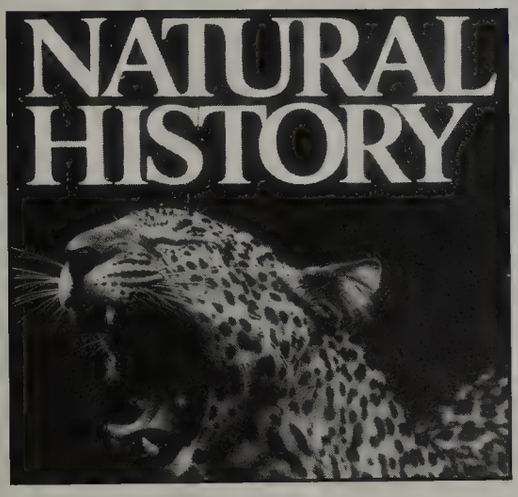
When I first dug up some burrows, I could see that they were made with care and were perhaps the key to understanding the beetles' adaptation. The mud is firm and will hold any shape into which it is sculpted; a pencil hole made in the surface will last for many weeks. To study the burrows' shapes and preserve the eggs in place, I filled a few burrows with clear silicone resin. When the clear, hardened resin cast was removed from the mud, the egg chambers, each containing an egg, resembled miniature table-tennis balls stuck to the burrow's characteristic "wine bottle" shape. The burrow is about two a one-half inches long, with a living cha ber one-quarter of an inch in diameter; narrow neck three-quarters of an inch lo opens out to the surface. The individu egg chambers extend from the livi space.

I saw no evidence that burrows ever b come flooded, even at high tide. To fi out why, I sculpted an artificial burrow clear agar (the kind of gel used for bacte ial plates) and then submerged it. At fi the narrow neck seemed effective in kee ing the water out, while artificial burro with wider openings quickly becar flooded. Eventually, however, even na row-necked burrows took on water. Sin this didn't happen in the field, I introduc a female beetle into one of my transpare burrows to observe her during my artific "high tide." A few minutes after the "tid began, the beetle suddenly ran up to t burrow neck and sealed the entrance wi a neat plug of agar "mud," taken in mout fuls from the walls. When I tested for t same behavior in the salt marsh, burro from which I removed the female did i deed flood, while those with a female i side remained dry. Rather than anticipa the tide and block their burrows in a vance, females can continue to feed un the very last moment, when the wat reaches their doorstep.

A dry, sealed burrow poses other da gers, however. Salt-marsh beetles usual burrow into "blue" mud, which is tightly compacted that it allows no oxyg into the burrows. (This mud is unlike t surrounding, looser, aerobic "brow mud, which is tinged by iron oxides.) Du ing low tide, when the burrows must be

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opened to allow oxygen replenishment, each beetle pushes up a new heap of tailings as it clears the entrance of washed-in debris. Only by plugging and unplugging her home in sync with the tides can a female salt-marsh beetle rear eggs and larvae in the airless mud—a life style very much like that of fiddler crabs.

For most of the year, male *Bledius* dig burrows very similar to those of females, but without the egg chambers. During the spring, they walk the marsh surfaces in search of mates, pausing at burrow entrances. If caught by the tide during their search, males grip the mud and flip their abdomens over their heads to create an air bubble. After the tide subsides, those that remain continue their search, but many have been washed away. When he finds a female that allows him access, the male stays with her for some hours underground, where copulation takes place. Right after mating, the male leaves and goes in search of another female.

After fertilization, the female lays an egg every other day in an individual chamber off the main burrow. After about twenty-seven days, the first-instar larva hatches, crawls into the main living chamber and begins to feed on its mother's algae collection. Eight days later, it leaves to dig its own burrow. After six more days, it molts into a second instar; then into a third, thirteen days later. It remains in its third and final instar stage for twenty-eight days. Finally, it spends about fifteen days as a pupa. A beetle's development from egg to adult takes about a hundred days during a British summer.

Since older larvae were found alone in their own burrows, I wondered at what stage they venture above ground. William Foster, of Cambridge University, and I went to the salt marsh about midnight with red flashlights to observe the tiny first instars. They come out only at night and walk over the beach exploring every crevice and dimple in the mud. (They were very interested in a hole I made with a pencil point.) If a larva ventures into an occupied burrow, the owner chases off the intruder, which continues to search for a home. Within dense colonies, the young larvae roam in tight circles during their search, but run quickly in straight lines through areas without burrow entrances. These movement patterns (also used by parasitoid wasps hunting for hosts) tend to keep the larvae within the colony.

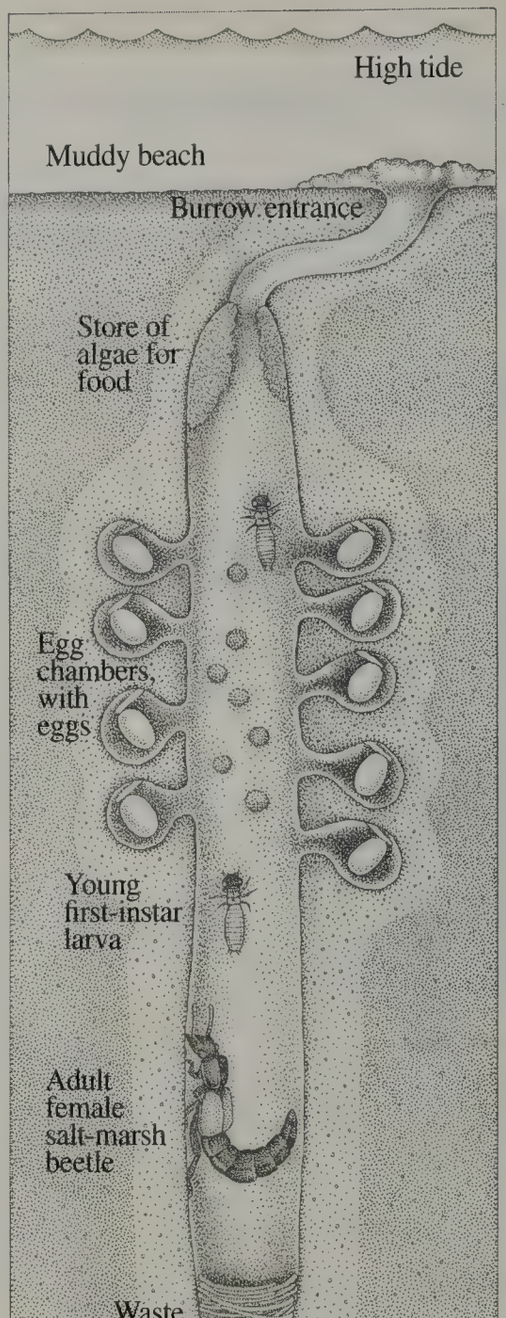
For the dispersing larvae, survival is a race against two clocks. They have to find or dig a burrow before the next tide washes them away or before the sun rises, whichever comes first. At night most predatory shorebirds are asleep. The mud is cool and damp, making burrowing easy. The air is relatively humid, so the larvae (accustomed to high humidity below ground) do not risk drying out. On a summer day, the salt-marsh surface is a baking desert covered with salt crystals.

By emerging at night, the instar larvae are protected from some hazards, but are exposed to others. During our nocturn prowls, we noticed hundreds of carab beetles, whose numbers on the mudd beach peak about midnight. Before lon we saw one bump into a first-instar sa marsh beetle and eat it. Soon we realize that all over the marsh, *Bledius* larv were being gobbled up. As though in game of "blindman's bluff," the predato lunged in the direction of larvae as soon their antennae touched one. Sometim larvae escaped by suddenly running bac ward or forward (they can move just fast in either direction) or by jerking the heads. With such tactics, they were able escape about half the encounters wi carabids. But when we plucked new hatched first instars from maternal bu rows and placed them on the beach, the were always caught. And when we r moved females, we found that the burrow were soon invaded by carabid adults th fed on newly hatched larvae.

Once a larva has successfully emerge run the midnight gauntlet on the beac and dug itself a home, it may be safe. Mo predators are too large to descend into larva's burrow, which is very similar that of an adult. For the rest of its life, t larva does not travel again, coming up the burrow's entrance only to collect alg as adults do, and enlarging its burrow as grows. Unlike adults, the larvae leave the feces neatly at the side of the burrow, i stead of at the bottom.

One summer, we were fascinated to s a female parasitoid wasp walking alon the flat mud, stopping at each heap of be tle tailings. We marked each one she vi ited with a little numbered flag. With ninety-nine minutes she had visited sixt two heaps, walking a total of fifty-ni feet, but there was more to the story. Aft investigating some heaps with her ante nae, she quickly moved on. At others sh patted the little mound with her antenn and then vigorously probed with h ovipositor to find the hole hidden below. successful, she lifted up her wings an ovipositor first, disappeared down the bu row for up to six minutes. Undergroun we learned later, the wasp had attempte to paralyze the resident larva with its sti in order to lay a pearly white egg inside i body. Why did she behave so different on different heaps? To find out, we dug u the burrows beneath each heap she ha touched. When a burrow contained a lo larva, the wasp had usually entered, but an adult female was present, in thirteen o of fourteen cases the wasp did not enter.

When the female beetle is with h



The watertight burrow made by the female salt-marsh beetle enables her to raise a brood in intertidal zones. During high tides, she seals the entrance with mud, uncovering it later to admit air.
Patricia J. Wynne, after Poul Winter

ung, she defends them vigorously. Her od-sized jaws can nip, and she also lifts r poison-tipped abdomen over her head jab at an intruder. Glands in the tip emit xious chemicals, some of which smell ong even to humans. Perhaps the pun- nt odor of adult females alerts the wasps stay away from guarded burrows.

A parasitoid wasp that hatches out of a etle larva must emerge from its pupa, ate, and find salt-marsh beetle larvae to rasitize, all between tides. Once inside e unfortunate beetle larva, the wasp's g is protected from saltwater and preda- rs. After depositing her eggs, a female asp is swept up in the next tide and ends lifeless flotsam. When mature, the wasp rva bursts out of its living larder and ins a cocoon. It will overwinter in the amber its host dug as its last act, emerg- g as an adult wasp the next summer.

Parental care appears to have evolved dependently in several groups of beetles similar environments. Ecologist Ellinor arsen, working in Danish salt marshes in e 1930s, found two other species in hich the mother digs narrow-necked bur- ws and remains with her eggs. (The ree species belong to unrelated beetle milies: the Staphylinidae, Carabidae, nd Heteroceridae.)

When she compared close relatives of e salt-marsh beetles, Larson found one ecies that lives a few yards below them n the shore and also cares for its eggs and rvae. However, other closely related spe- ies that inhabit the high marsh or sand unes, rarely covered by tides, do not ow any parental care at all. Apparently, ecies that burrow in fast-draining, aer- ted, sandy beaches can also safely leave eir eggs. So parental care seems to be an daptation to the combined dangers of dal flooding and airtight burrows. Addi- onal advantages, such as foiling preda- rs and reducing larval parasitism, were econdary gains.

After some years, beetle burrows hon- ycomb the muddy shore, increasing aera- ion and drainage. Now the soil is just right or bushy salt-marsh plants that move in nd proliferate, shading and killing the lgae on which beetles feed. Soon, only bandoned burrows remain under these ushes, and the beetles must find a new oung marsh to colonize. Neither time nor ide waits for these beetles.

Tristram Wyatt is a research associate in the Department of Zoology and a univer- sity lecturer in the Department of Contin- uing Education, University of Oxford.

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Poe's Greatest Hit

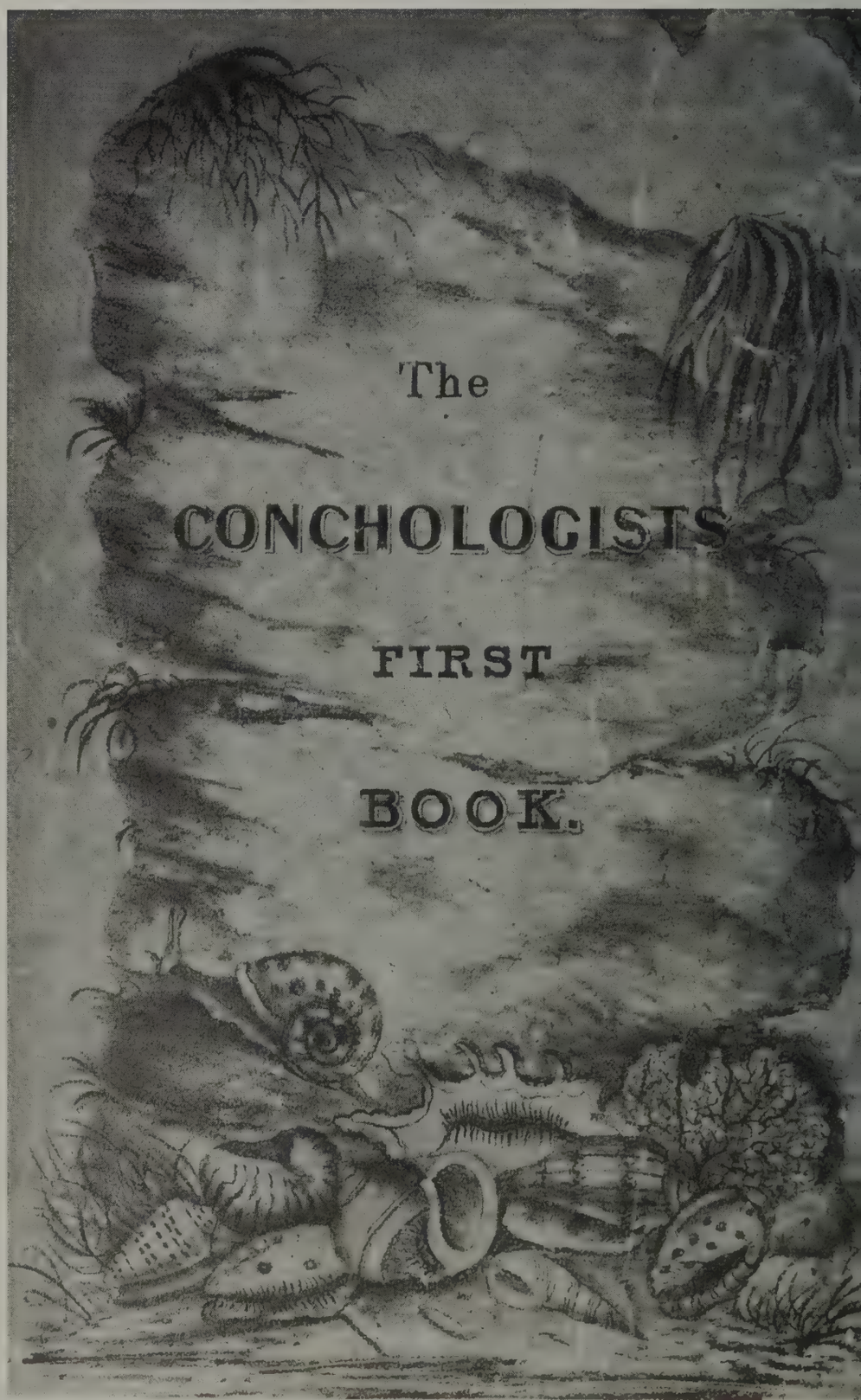
Why did the hard-drinking, urbane American poet write an innovative textbook about seashells?

by Stephen Jay Gould

Posthumous recognition may be good for the soul, but most artists would prefer a bit of bodily succor during their hours of earthly need. Edgar Allan Poe (1809–1849) published his first work, *Tamerlane and Other Poems,* in 1827 at age eighteen. He paid the costs of publication himself and produced but fifty copies. Only twelve have survived, making this work the rarest and most expensive of all American first editions. The latest auction records may be stupendous, but Poe's pamphlet received neither literary attention nor sales at its debut.

Here is a trivia question on the same subject: Can you name the only book by Poe that was successful enough to be republished during his lifetime? The answer? *The Conchologist's First Book: or, A System of Testaceous Malacology, Arranged Expressly for the Use of Schools,* published in 1839. The first edition, at a price of $1.75 per copy, sold out in two months, leading to a second, enlarged edition in 1840, and a third in 1845. For all of Poe's other work, from the House of Usher to the Rue Morgue, we can only intone the entire vocabulary of his most famous character, the raven: "Nevermore." No second edition for any other book during Poe's lifetime.

We need not always marvel when celebrated people boast accomplishments far from the source of their fame. Henry VIII wrote quite acceptable pieces of music; but why not, for he was intellectually inclined and well educated in the various arts of Renaissance humanism. Leonardo da Vinci designed formidable machines of war; but why not, for princely patrons needed his practical skills even more than his painter's art. But nothing about Edgar Allan Poe's life suggests any abiding concern with natural history. We can picture him drunk and penniless in Philadelphia or New York, but who can conjure up an image of Poe wandering through the



Cover of the low-priced textbook written by Edgar Allan Poe

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woods or strolling along the seashore "dreaming dreams no mortal ever dared to dream before"? His various literary creatures—the raven, the ape of the Rue Morgue, or the black cat—evince no particular knowledge of zoology. His biographers have had a most difficult time trying to suggest any source for Poe's potential interest in seashells. (Some have suggested that Poe may have known the naturalist Edmund Ravenel while he was stationed on Sullivan's Island in Charleston Harbor during an army hitch in 1827 and 1828. Others point to a description of some shells in one chapter of his novella, *The Narrative of Arthur Gordon Pym.*) We may well conclude that *The Conchologist's First Book* is a most "quaint and curious volume," a true anomaly in the life of a literary man.

We may better understand Poe's methods and motivations in writing the utterly forgotten best seller of his lifetime when we acknowledge the ambiguous status of *The Conchologist's First Book*—basically a scam, but not so badly done. Poe didn't need much scientific knowledge to fulfill his appointed role as part name lender, part literary man, and part plagiarist. Poe's friend Thomas Wyatt had, in 1838, published a lavish and expensive book on mollusk shells, retailing for eight dollars a copy. Sales were predictably slow, and Wyatt wished to produce a shorter edition with uncolored plates at a much lower price. But his publisher, Harper, objected, citing a reasonable concern that its fancy edition would then become entirely unsellable. Wyatt, still wishing to proceed, but fearing legal action should he publish the shorter version under his own name, sought a surrogate to help with his new volume and to serve as name-bearer for a flat fee.

Poor Poe, perennially broke and often drunk, seemed ideally suited for the role. Others have shaken the world for thirty pieces of silver, but Poe apparently received fifty dollars for both fronting and helping in preparation of *The Conchologist's First Book.* (Details of the financial arrangements have been lost, but I suspect that the anonymous Wyatt received royalties on the successful product.)

I have tried to survey all the standard biographies of Poe, and they are unanimous in their severe discomfort with *The Conchologist's First Book.* None gives this episode more than a page or two—a quick acknowledgment followed by an apparent search for "respite and nepenthe" (the drug of forgetfulness). F. T. Zumbach states that "it didn't bear even the slightest relevance to Poe's literary career" (*Edgar Allan Poe: Eine Biographie,* Winkler Verlag, 1986). Julian Symons, an excellent writer of detective fiction, as well as a li erary biographer, writes that Poe "put h name to a piece of hackwork" (*The Tel Tale Heart: The Life and Works of Edga Allan Poe,* Harper and Row, 1978—iron cally, Wyatt's old publisher). David Sin clair describes *The Conchologist's Fir Book* as "a piece of shameful hackwork t which only desperation could have drive him" (*Edgar Allan Poe,* J. M. Dent an Sons, 1977). Jeffrey Meyers labels th book as Poe's "grossest piece of hack work" (*Edgar Allan Poe: His Life an Legacy,* Charles Scribner's Sons, 1992).

I do not write this essay either to exon erate Poe or to revise the usual story abou the genesis of *The Conchologist's Fir Book* in any substantial way. By moder standards and copyright laws, Poe woul either be in jail (along with Wyatt an other collaborators) or in the dock awai ing conviction and a fat fine. But I do wan to suggest that Poe's biographers need no be so apologetic and should not treat Th *Conchologist's First Book* as a curious an shameful anomaly best passed over in nea silence. I want to suggest, rather, that Poe book succeeded because it filled a need i a competent and at least mildly innovativ way (whatever the dubious circumstance of the volume's origin); moreover, whe we grasp the reasons for its success, w learn something interesting about popula education in nineteenth-century America

To analyze *The Conchologist's Firs Book* properly, we must first understan the genesis of the volume's various parts and Poe's role in cobbling them togethe (Remember that Poe's name fronted fo the efforts of a committee. Wyatt certainl worked on the book, and others may hav helped as well.) We get our best evidenc from Poe's own testimony—a typicall self-serving letter with an undeniable pos itive spin, but true in its particular claim so far as I can tell.

Poe led a short and tortured life (follow ing an old quip usually made abou Mozart, I am tempted to say that Poe wa eleven years dead when he reached m age—and I'm still a kid by my own reck oning). Poe created all his own devils— the fights, the near duels, the bouts o drunkenness, the endless and debasin pleadings for money, the vituperative liter ary disputes. He haunted himself with line from his most celebrated poem:

> Is there—is there balm in Gilead?—
> tell me—tell me—I implore:
> Quoth the Raven, "Nevermore."

Poe counted several charges of plagia



"Were you expecting the Azalea-watchers?"

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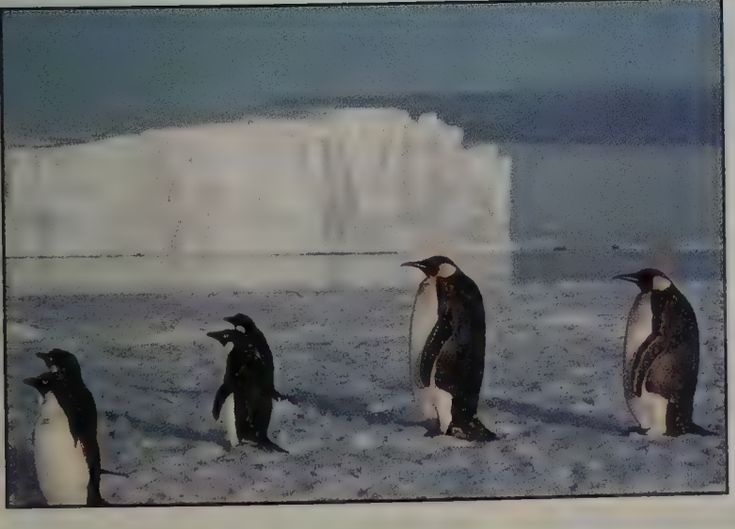
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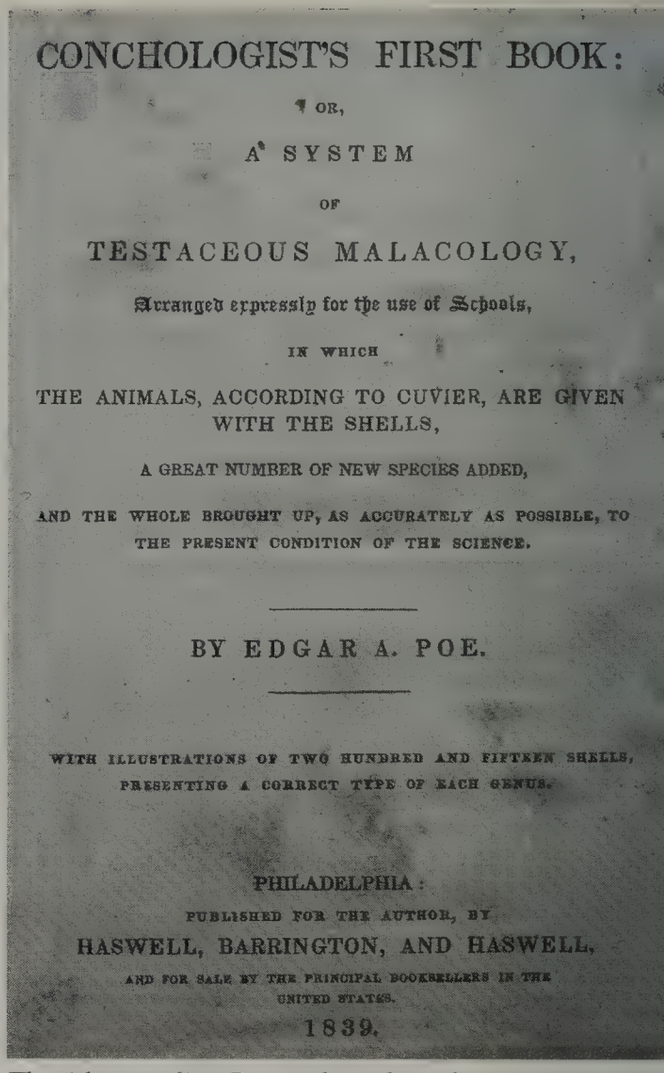
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rism (some true) among his many troubles, and he spent much of his last decade threatening and bringing legal suits against such accusations. *The Conchologist's First Book* did not escape this pattern. In February 1847, Poe learned that a Philadelphia journal had questioned his foray into natural history—and he responded with a letter to George W. Eveleth:

What you tell me about the accusation of plagiarism made by the "Phil. Sat. Ev. Post" surprises me. It is the first I heard of it.... Please let me know as many particulars as you can remember—for I must see into the charge—Who edits the paper? Who publishes it? etc. etc.—about what time was the accusation made? I assure you that it is *totally* false. In 1840 [Poe is a year off here] I published a book with this title—*The Conchologist's First Book*.... This, I presume, is the work referred to. I wrote it, in conjunction with Professor Thomas Wyatt, and Professor McMurtrie of Ph[iladelphi]a—my name being put to the work, as best known and most likely to aid its circulation. I wrote the Preface and Introduction, and translated from Cuvier, the accounts of animals etc. *All* schoolbooks are necessarily made in a similar way. The very title page acknowledges that the animals are given "according to Cuvier." This charge is infamous and I shall prosecute for it, as soon as I settle my accounts with the Mirror.



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AND THE WHOLE BROUGHT UP, AS ACCURATELY AS POSSIBLE, TO THE PRESENT CONDITION OF THE SCIENCE.

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PUBLISHED FOR THE AUTHOR, BY

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1839.

The title page lists Poe as the only author, although the book was a joint effort.

The Conchologist's First Book begins with a two-page "Preface," and I have no reason to doubt Poe's claim that he wrote this part all by himself. A four-page "Introduction" then follows—and now the trouble begins. Poe expropriated much of this text from the fourth edition (1836) of a British work by Capt. Thomas Brown, entitled *The Conchologist's Text-Book* (Glasgow: Archibald Fullarton and Company). Some biographers have claimed that Poe's entire text is a paraphrase, if not a direct copy, of Brown's. (F. T. Zumbach, for example, writes that Poe "copied from Brown almost word for word.") By my own comparison between the two books, only three paragraphs (about one-fourth of the text) show extensive "borrowings." (Poe wins no exoneration thereby, for pla giarism, like pregnancy, does not increas in severity by degrees: beyond a point c definition, you either did it or you didn't– and Poe surely did.)

The plot thickens with the next sectio of twelve plates. The first four, illustratin the parts of shells, are lifted in toto, jot fo jot and tittle for tittle, from Brown. N fuss, no pretenses, no excuses—just plai stolen. The subsequent eight plates, illus trating the genera of shells in taxonomi order, follow Brown in the more interes ing pattern of back to front—that is Brown's last plate is Poe's first (with con siderable rearrangement, reorientation and switching around of individual fig ures), and we then move up through Poe book and down in Brown's, until Poe's las plate largely reproduces Brown's first.

Others have caught the pattern and eve suggested that Poe and Wyatt were nov consciously trying to hide their plagia rism. The actual reason is different an more interesting. (What could Poe an Wyatt be trying to hide anyway after copy ing the first four plates exactly?) Brown book follows the pedagogical scheme o

great French naturalist Lamarck, who
vays presented his discussions in chain-
being order, but top down rather than
e more conventional direction of bottom
. That is, Lamarck began with people
d ended with amoebae, rather than
e usual vice versa. Brown followed
marck and therefore started with the
ost "advanced" mollusks, but Poe and
yatt obeyed the usual convention and
gan with the most "primitive"—hence
e reversed order.

The choice of Brown as victim best il-
strates the nature of the scam, or at least
e easy-street methods, followed by
yatt, Poe, and company in producing
eir cheap edition of a molluscan text-
ok. The key lies in Glasgow, home of
own's publisher. No effective interna-
nal copyright existed in Poe's day, and
aterial published in foreign nations
uld be plagiarized and expropriated
thout fear of legal reprisal (moral sanc-
ns existed, just as today, but principles
thout practical power have never been
ry effective as instruments of persua-
on). Brown was British and therefore
minently exploitable. (For the same rea-
n, exactly forty years later, Gilbert and
llivan brought their entire troupe to
merica to stage the première of the *Pi-
tes of Penzance* in New York, thus to
stage the theatrical pirates who had
ade so much money, without paying a
nt in royalties, from Gilbert and Sulli-
an's previous smash hit, *H.M.S.
inafore.*) Poe must have felt at least min-
nally guilty, for he penciled corrections
to his own copy of *The Conchologist's
irst Book*—including the following addi-
on to the acknowledgments: "[Thanks]
so to Mr. T. Brown upon whose excelent
ic] book he has very largely drawn."

The next section of *The Conchologist's
irst Book,* a ten-page "explanation of the
arts of shells," also derives verbatim
om Brown, with a few minimal changes
simplify terminology and eliminate
ritish parochialisms. The body of the
ook then follows—some 120 pages de-
cribing each genus, the animal first and
en the shell, and concluding with a list of
l species within the genus. This section
llows the order of Wyatt's more expen-
ve book. Poe apparently excerpted mate-
al from Wyatt on the shell of each genus
nd translated passages from Cuvier's
rench to supply descriptions for the soft
natomy of the animals within. (Poe's re-
emption, I will argue, comes from this
ontribution and its rationale.) *The Con-
hologist's First Book* ends with a glossary
and index, apparently supplied by Wyatt.

Plagiarism? Yes, in several parts. Shameless hack work? I'm not so sure—for Poe did an interesting thing or two that gave the book some value. Evolutionary biologists know, better perhaps than members of any other profession, that historical origin and current utility represent different facets of a biological object and that one need not be correlated with the other (a frequent theme of these essays). We should apply the same distinction to Poe's book. I will not defend its origin, but the final product had genuine utility (and at least a dollop of innovation)—and its commercial success was no fluke. To appreciate these legitimate reasons for success, we must ask two questions: why did Wyatt call upon Poe and not someone else, and for whom was the book intended?

1. *Poe's genuine expertise.* Poe gives one reason for his selection as "front man" in his letter to Eveleth, previously quoted: "my name being put to the work, as best known and most likely to aid its circulation." If this claim can be accepted at face value, then we have some interesting (if also interested) testimony that Poe had



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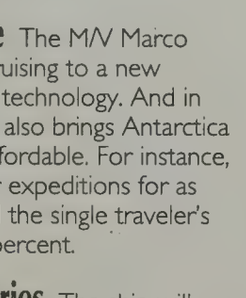
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achieved some measure of literary recognition and was not the abject failure or utterly misunderstood genius of so many later portrayals.

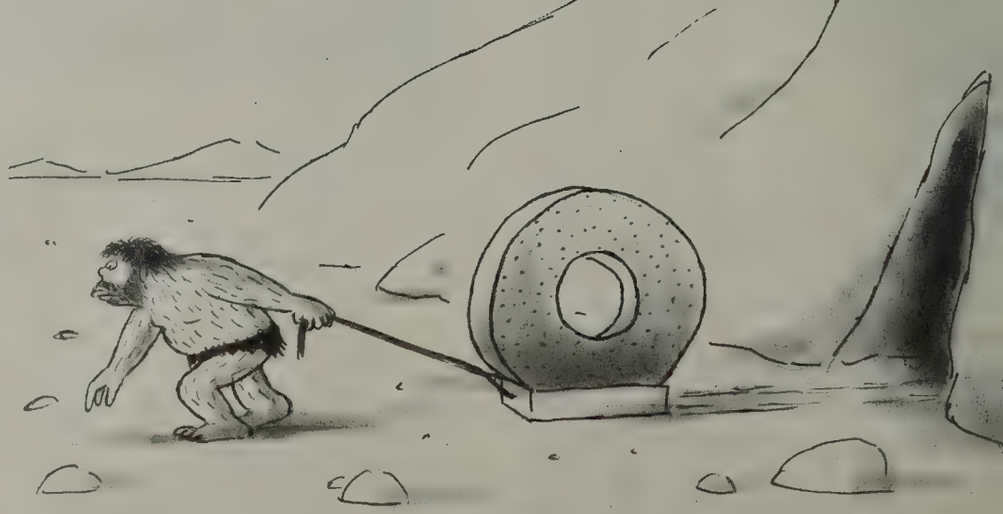
But I suggest that Poe's selection also recorded Wyatt's good judgment about particular skills for the job required. *The Conchologist's First Book* presents, as an explicit and fundamental feature of its organization, a progressive, even innovative, arrangement of material. None of Poe's biographers have ever picked up on this theme, probably because the arrangement seems so "obviously" right that we assume its employment in books about mollusks from all times. Not true. The arrangement was unusual in Poe's day—and I suspect that Wyatt needed Poe's skills to implement the reform.

The name of the phylum Mollusca comes from a Greek word for "soft" (as in mollify or mollycoddle)—a reference to the animal that, without a skeleton inside its body, secretes a calcareous shell for an enclosure. Most collectors and natural history buffs, for obvious reasons, focus upon the preservable shell, not the quickly decomposed body. The study of shells and their classification goes by the separate name of conchology—as in Poe's book.

In Poe's day, most popular books on mollusks treated the shells alone. Wyatt's original and expensive version only described the shells, as did Brown's volume, the source of Poe's plagiarism. Linnaeus himself had based his classification of mollusks only upon shells. As an example, in the popular work on mollusks featured in last month's essay—*The Conchologist's Companion,* published in 1834 and ther fore a contemporary of Poe's volume author Mary Roberts begins her text separating the study of animal and sh and by defending a treatment based or upon shells and ignoring animals entirel "The elegant science of Conchology, r friend, comprises the knowledge, arrang ment, and description of testaceous an mals; a science, according to Linnaeu which has for its basis the internal for and character of the shell, and is totally i dependent of the animal enclosed with the calcareous covering." And Thom Brown added in 1836: "It is upon the e clusive shape of the shell, not the anim inhabitant, that the Linnaean arrangeme of Conchology is formed."

Wyatt and Poe may have plagiariz Brown, but they did improve upon his o ganization, and this entailed some effo that deserves more than the epithet "hackwork." An arrangement based on upon shells, and ignoring the biologic manufacturers of these coverings, mu largely represent an exercise in artifici pigeonholing and simply cannot provi an optimal account of molluscan life. more integrated and fully biological di cussion must present information abo animals and shells together. Wyatt and P decided to provide this dual treatme (even though Wyatt had failed to do so his more elaborate volume)—and not or whim or as a nice little sidelight, but as t fundamental feature of their new volum

Poe's two-page preface is little mo than a rationale for this defining feature the new volume. He begins with defi



ns, contrasting malacology (study of all ological aspects of mollusks) with con- ology (consideration of shells alone). e then states that he will keep the more miliar name of conchology, but intro- ce the important biological innovation describing both the animals and shells gether:

e common works upon this subject how- er, will appear to every person of science ry essentially defective, inasmuch as the lations of the animal and shell, with their pendence upon each other, is a radically portant consideration in the examination either.... There is no good reason why a ok upon Conchology (using the common rm) may not be malacological as far as it oceeds.

Poe then reinforces his intent by de- ribing the new book's "ruling feature"— hat of giving an anatomical account of ch animal, together with a description of e shell which it inhabits." (Incidentally, e most recent biography of Poe, pub- shed in 1992, misses this point by failing recognize the conceptual reform behind oe's focus upon disciplinary names nalacology vs. conchology]. The author rites that "Poe's boring, pedantic and air-splitting Preface was absolutely guar- nteed to torment and discourage even the ost passionately interested schoolboy.")

But where to get the descriptions of an- nals, since neither Wyatt's nor Brown's olume contained such information? They rned to France, the leading nation by far natural history during the early nine- enth century (the English would over- ke them later), and to the work of Eu- pe's greatest anatomist, Georges Cuvier. nd now Poe's particular skills came to e fore.

Poe had no known expertise in natural istory, but he was certainly fluent in rench. Poe's actress mother had died hen Poe was only two, and he had been aised in the home of an intermittently ealthy Richmond businessman, John llan (from whom Poe took his middle ame, although he was never formally dopted). He lived in England and Scot- and for five crucial years (1815–1820), here he received a classical education in igorous schools, including a thorough rounding in French. His intense training n ancient and modern languages then ontinued in Richmond. He attended reparatory schools and then spent a year t the University of Virginia in 1826, here he probably met Thomas Jefferson ust before the great statesman's death; and here two ex-presidents, James Madison

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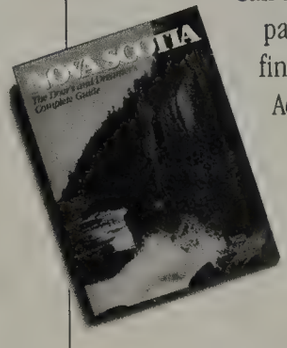
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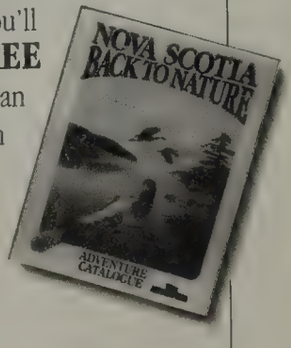
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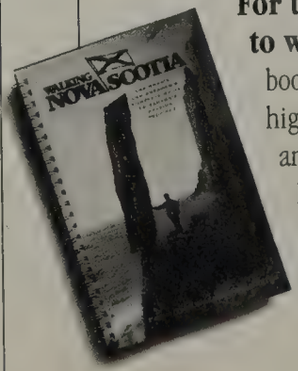
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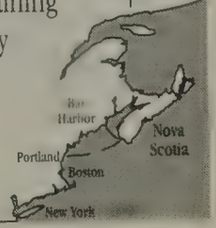




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(who had succeeded Jefferson as rector) and James Monroe, examined him for several hours and gave him highest honors in both classical and modern languages. In short, Poe surely knew his French, probably better than anyone else engaged in the project of downsizing and upgrading Wyatt's book.

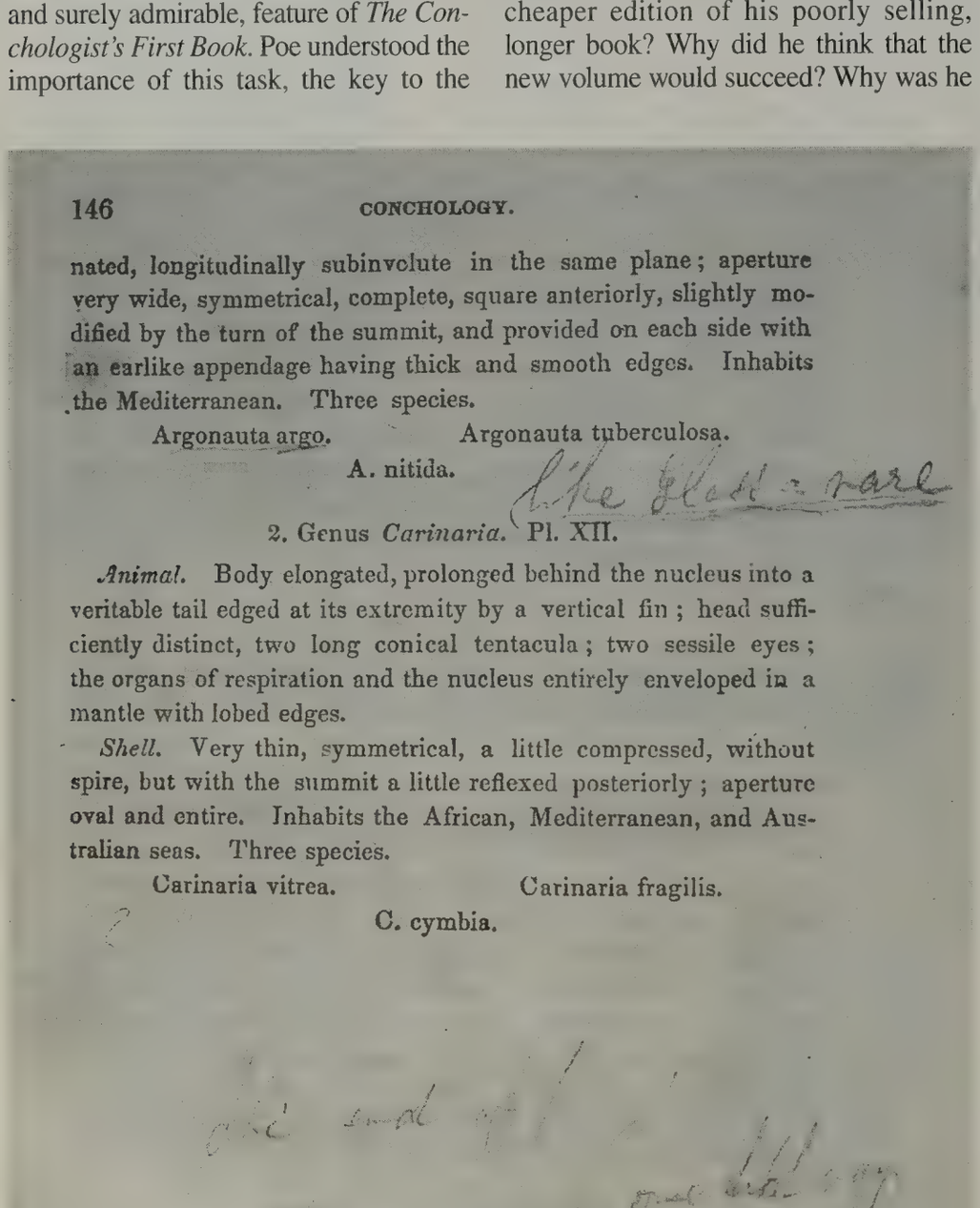
I do not know how much time Poe spent translating Cuvier's accounts of the animals and integrating them with Wyatt's more conventional material on shells alone. But this effort defined the central, and surely admirable, feature of *The Conchologist's First Book*. Poe understood the importance of this task, the key to the book's distinction and success, for he stated in the letter to Eveleth: "I wrote the Preface and Introduction, and translated from Cuvier, the accounts of the animals." I do not claim that Poe spent many a "midnight dreary" pondering himself "weak and weary" over Cuvier, but the effort required some time, demanded a linguistic skill perhaps not widely spread in Wyatt's circle, and provided the central ingredient to the book's legitimate success.

2. *The book's intended audience.* But why was Wyatt so eager to produce a cheaper edition of his poorly selling, longer book? Why did he think that the new volume would succeed? Why was he so keen that he was even willing to aban don any advantage of explicit authorshi to maneuver around the concerns, and th legal arm, of his original publisher?

To answer these questions, we need t make the right analogy to the most compa rable modern phenomenon—musical per formers who tote tapes and CDs of thei work to hawk at intermissions during thei concerts. *The Conchologist's First Boo* did not sell primarily in bookstores (many or any existed in early nineteenth century America). Wyatt had a specific dedicated market—and he really neede an inexpensive product to sell. Presenter of popular science now teach in schools o frequent the true "midnight dreary" of ou modern age—late-night radio talk shows But a nineteenth-century counterpart t Jacques Cousteau or David Attenboroug hit the traveling circuit as an itinerant lec turer to the various lyceums, athenaeums book circles, and ladies' and gentlemen clubs (usually separate) that kept the fir of learning alive in every substantial tow of nineteenth-century America. Thoma Wyatt was one such traveling salesman o science—and he needed a book to accom pany his frequent and popular lecture se ries on mollusks. I don't claim that his mo tives were entirely, or even to any larg extent, idealistic. His need probably trans lated to dollars for his pocket. Lecture fee were small, and the supplement added b heavily promoted book sales to a willin audience probably meant the differenc between penury and solvency (the glitz expansion of museum shops in our ow times has occurred for the same reason) Remember that Poe got a flat fee for a li tle writing, some translation, and the loa of his name; Wyatt, no doubt, was recom pensed on a per-copy basis.

Nonetheless, I must again invoke th distinction between reasons for origin an sources of utility. Wyatt may have joine with Poe almost entirely for the money but they promoted a good and innovativ idea—elevating conchology from artificia description to integrative biology—by in sisting that animals and shells be de scribed together. Their product was surel worthy, if not brilliant or pathbreaking (fo Poe lacked the biological knowledge to in tegrate his translated material on animal with Wyatt's old description of shells an therefore did little more than list on source of information above the other).

I have a copy of *The Conchologist First Book*. (I could never dream of own ing something like *Tamerlane and Othe Poems,* but Poe's shell book was a success



146 CONCHOLOGY.

nated, longitudinally subinvolute in the same plane; aperture very wide, symmetrical, complete, square anteriorly, slightly modified by the turn of the summit, and provided on each side with an earlike appendage having thick and smooth edges. Inhabits the Mediterranean. Three species.

Argonauta argo. Argonauta tuberculosa.

A. nitida.

2. Genus *Carinaria.* Pl. XII.

Animal. Body elongated, prolonged behind the nucleus into a veritable tail edged at its extremity by a vertical fin; head sufficiently distinct, two long conical tentacula; two sessile eyes; the organs of respiration and the nucleus entirely enveloped in a mantle with lobed edges.

Shell. Very thin, symmetrical, a little compressed, without spire, but with the summit a little reflexed posteriorly; aperture oval and entire. Inhabits the African, Mediterranean, and Australian seas. Three species.

Carinaria vitrea. Carinaria fragilis.

C. cymbia.

After a lecture, "Proff Wyatt" (Thomas Wyatt, the expert behind the shell book) probably sold this copy to its first owner for $1.75.

d therefore survives in many copies at nageable prices.) I never knew the rea- ns behind the copious pencil scribblings my copy until I did the research for this say. One of the blank pages at the back ars the inscription: "Lectures delivered fore the young ladies of Charlestown male Seminary" (probably in the settle- ent just east of central Boston and elled with a "w" and not in the city of uth Carolina, West Virginia, Illinois, or ississippi, rendered with a letter less as harleston). After the last page of Poe's nt anatomical and conchological de- riptions, the owner has written: "The d of Lectures on Conchology by Proff. yatt"—the clincher to my search for a urce (I had never heard of Wyatt before iting this essay and therefore had no ue to the meaning of the inscriptions). her jottings largely note the etymology Linnaean names or record popular des- nations under Poe's Latin. The owner, r example, writes "clam" under the nus *Mya* and, charmingly for its homo- mic mix-up, "muscle" when she means nussel" under the genus *Mytilus*.

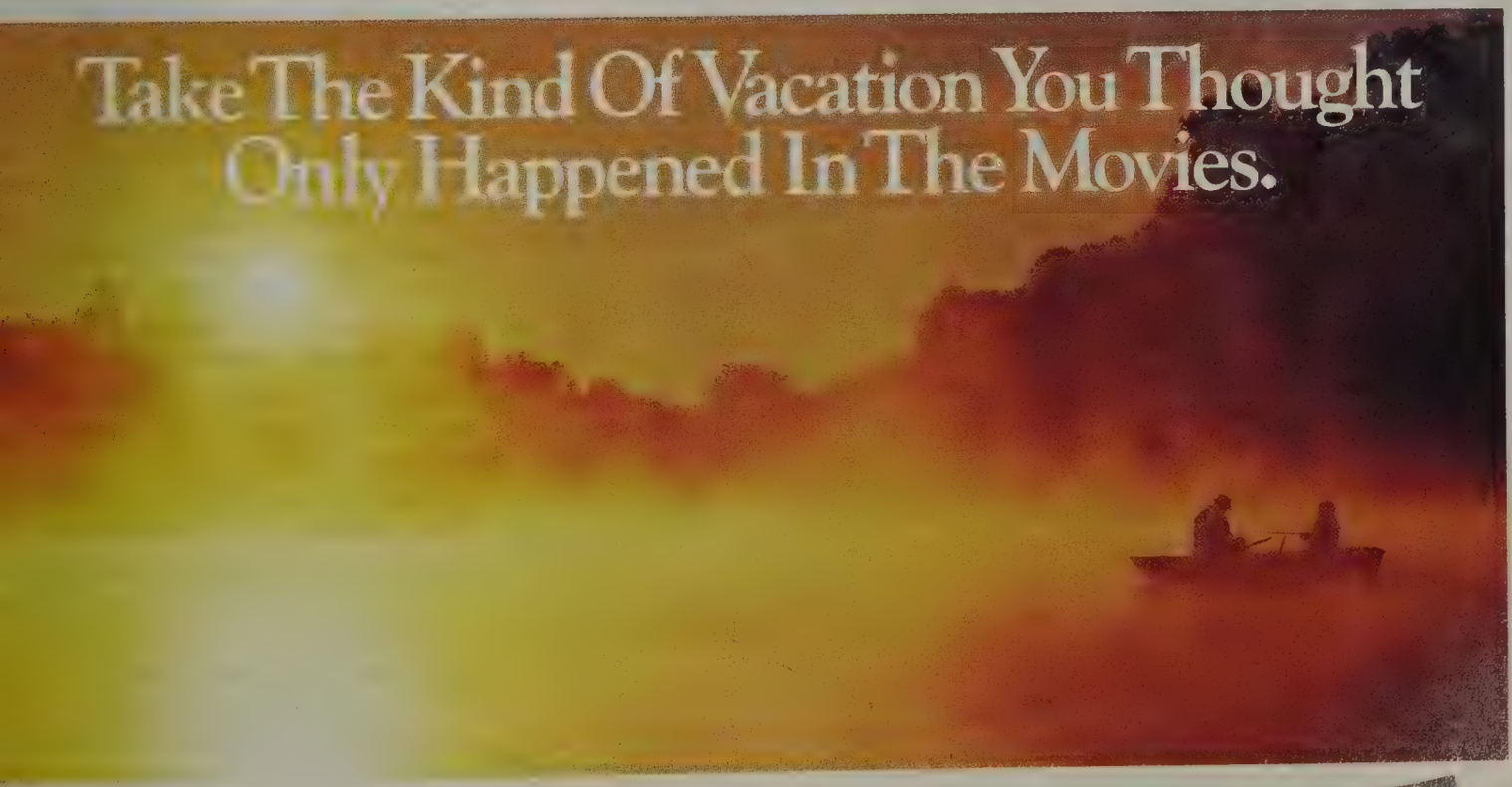
I don't know how else to make the oint, except by a simple confession of feelings. It is an enormous thrill for me to know that my copy of *The Conchologist's First Book* was toted by Wyatt to one of his lectures on mollusks, and sold to a woman in a neighboring town. I love to think of the book passing from Wyatt's own hand into the ownership of Ms. Charlestown, probably for two dollars forked over, and a quarter given in change. Chuckle if you will at my imagination, but the lyceum movement in America was one of the most worthy institutions ever spawned in an otherwise nonintellectual nation (the precursor to later Chautauquas and to all the popular education of our time). It also represented one of the few pathways then available to women for any group-based education. *The Conchologist's First Book* was a reasonable contribution to this movement, and my copy comes from the heart of a worthy effort.

I am therefore led to view Poe's most famous image in a different light from that intended by the author. Poe opens his window, thus admitting the raven who perches on his white bust of Pallas and never leaves:

> And the Raven, never flitting,
> still is sitting, *still* is sitting
> On the pallid bust of Pallas just above
> my chamber door.

Poe's raven is an ominous and tragic weight upon hope for psychological peace and dreams of accomplishment. But consider the union in another way. Pallas Athena (equivalent to the Roman Minerva), chaste goddess of practical reason and protector of cities (also name giver to Athens)—symbol of the urban and civilized, as opposed to Artemis, goddess of the outdoors. Does she not represent Poe, or at least his unrealized hopes? (Athena's two designations, pallas and parthenos—the Parthenon of Athens is her temple—refer to her purity and virginity. Poe calls her Pallas, and undoubtedly longed for the unsullied life that she symbolized.) The urbane Poe, dweller in cities, scholar of languages, no fan of natural history. And the raven, symbol of raw nature, imposed from without, but now firmly joined in a union of opposites: black and white, science and literature, nature and culture. Should we not cherish the juxtaposition?

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.



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V I R G I N I A

More Hang-ups

Are you talking to me?

by Roger L. Welsch

As I do every month, I took the manuscript of my previous column, "Phony Medium," up to my panel of review editors at Eric's Big Table Tavern. This time, instead of the usual baffled confusion, the reaction was a collective snarl of recognition. Telephones strike a sympathetic chord. The criticism from my cronies was that I had only touched on the most superficial and obvious problems of this collapsed system of alleged communication.

Some of their fury was directed at me and my longtime habit of using my answering machine to screen calls. "I'm calling you to do you a favor, and I have to listen to your idiotic message and then present some sort of case to convince you to talk with me," my pals complained.

Well, yes, I do that. I love my answering machine. I make noises of gratitude to it every day for all the pain it saves me. My idea of a life fulfilled is one in which I never answer another telephone call without a machine between me and the caller.

The second complaint from the fellows of the forum, however—call waiting—was one with which I could sympathize, thus redeeming my credentials as an ordinary mortal. I, and most of the rest of the people in the sane world, hope the idiot who came up with call waiting has to cool his heels at the Pearly Gates interminably while Saint Peter says, "Whoops, excuse me, I have a call on the other line."

Ever since I was just a little shaver, I have been amazed that I could be standing in front of a clerk in a store with money in my hand and he or she would choose to ignore me and instead answer a ringing telephone. "Parfenaffers Sundries. No, we don't have pita bread. I think you can get pita bread over at Callafarfel's Greek Market. Yes, I think we do have extrawide wax paper, but let me check," and the clerk goes off, leaving me waiting there with my money. In such situations, I have, when I could reach the telephone, taken the liberty of hanging up for clerks. The last time this happened I was in a Tulsa hotel, and I made the evening just about as miserable as I could for the idiot in charge. (I'll bet that the next time he ignores a guest with a reservation for a telephone call from someone who might or might not come by, he'll at least look up to see if it's me!)

Call waiting is like that. Here I am. I am talking with you. You hear a beep or see a light and you check to see if it's someone you would rather talk to. Well, thanks, but not with me you don't. I hang up. You can call me back. I don't have call waiting. You talk with me, you talk with *me*.

Eclipse Products, of Darien, Connecticut, has developed the only call waiting system I find tolerable—the Gotta Go. It is tolerable only because it isn't a call-waiting system. Gotta Go is a fake. You get a call you don't want, you talk a minute before you realize it, and then you just hit your Gotta Go button. It makes a sound like call waiting, which impresses the bejeebers out of your boring caller, and you opt out. Personally, I think you should have the backbone to have an answering machine or to tell obnoxious callers that your dog is choking and just barfed on the only manuscript of your 900-page novel—but then, to each his own.

I would be indignant about this sort of technologically assisted cowardice, but I've done it myself. I have scraped paper or a hair brush across a telephone handpiece to fake a bad connection. I have pretended that I couldn't hear a word the caller was saying. Once I held a telephone to my stomach to convince an unwanted caller that a volcanic eruption was imminent, the first in Nebraska for millennia.

I reserve my highest self-praise, however, for a telephonic fraud I invented the morning after my wife, Linda, gave birth to our daughter, Antonia. The delivery was long and difficult. I took Linda to the hospital at 4 A.M., and she gave birth to Antonia eighteen hours later. That means I didn't get a decent meal the whole day, had to take my nap on a hospital couch, and lost a full day's work. It was hell.

Furthermore, I got home about 4 A.M. the next day, and while Linda slept and relaxed, I had to make my own coffee and call all our relatives and friends. No rest for the weary, I shrugged heroically.

Well, I was pretty excited, as you can imagine, that Linda and Antonia were well, not to mention me. A little before dawn, I lay in the hammock in our backyard, contemplating the wonders of birth and the universe and digestion, and since I couldn't do anything more about birth and the universe at the moment, I lit up the barbecue, tossed on two enormous filets, and opened two bottles of good champagne. (I *opened* both of them because once you open champagne, it is wasteful to do anything but drink it.)

I think it was about 7 A.M. when I finished the steaks and champagne (I suppose Linda was still sleeping or maybe enjoying a hospital breakfast) and faced my next assignment—calling everyone. I went inside and looked at the list. I could call folks on the East Coast, where it was already an hour later, and cross the continent with my announcements as the sun moved. I got through five East Coast calls by 9 A.M.

Everyone wanted to know about Linda and Antonia and how much the baby weighed and how long she was and the color of her hair, so every call took at least a quarter hour, more likely thirty minutes.

ooked at the list again. I had another fif-
en East Coast calls and I was already be-
nd on the Midwest schedule. I was fac-
g maybe two solid days of telephone
lls. And bankruptcy.

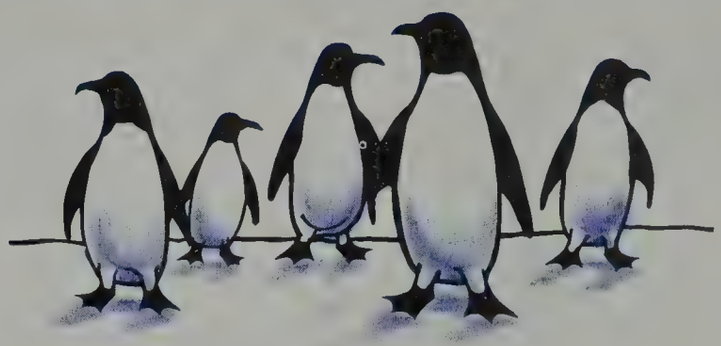
I was about to call a particularly loqua-
ous friend. I looked at my list. I contem-
ated our telephone bill. About this time
e champagne, always an inspiration for
e, kicked in, and I invented the Roger
elsch Calling Machine. I dialed my talk-
ive friend's number. The phone rang. He
swered. And I took off: "This is Roger
elsch's calling machine. Believe me,
oger would like to call you this morning,
t he is busy comforting Linda, who at
):20 P.M. gave birth to a beautiful eight-
ound, six-ounce baby girl, who will be
nown as Antonia Emily Celestine
elsch. Rog will try to get back to you
ter with more details, but even if he
oesn't, he and Linda know you'll under-
and."

And I hung up the telephone. Fifteen
conds and I was done. I couldn't believe
y genius. I finished off the list by noon
nd had another bottle of champagne and
nother filet. Our friends and relatives
ought we were really classy, using a call-
g machine so they could get information
ven while we were tied up with the won-
ers of birth.

There you have it: bad technology in
ood hands can be dangerous, and good
echnology in bad hands can be dangerous,
ut human virtues like sloth, mendacity,
nd overindulgence can go a long way to-
ard mitigating the damage. Think of the
hone system as a challenge: No matter
ow efficient the telephone becomes, you
an make it work.

olklorist Roger L. Welsch lives on a tree
arm in Dannebrog, Nebraska.

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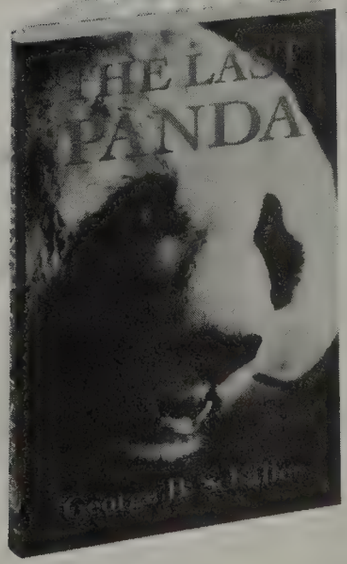


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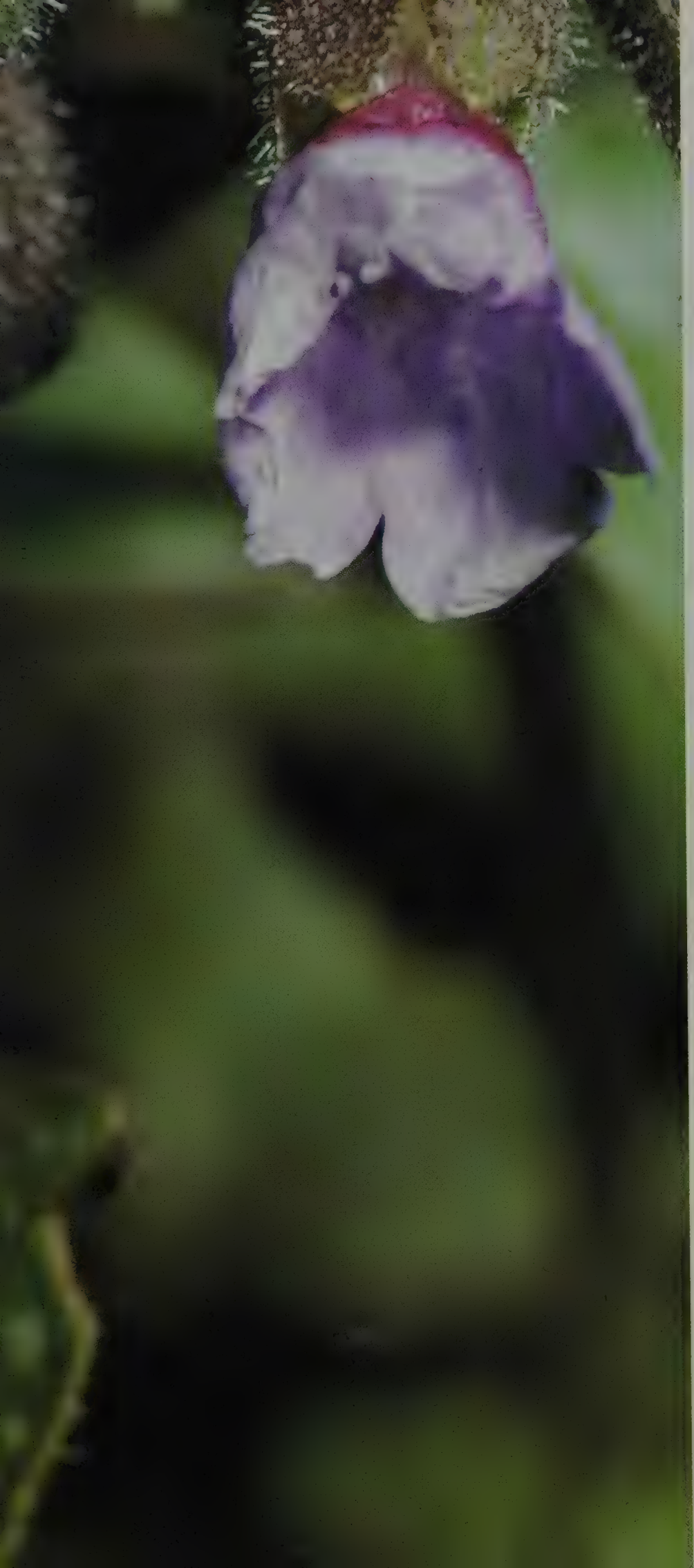
*Devra G. Kleiman, *The Washington Post Book World*

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A male flower bee, Anthophora plumipes, *collects nectar from a lungwort blossom.*
Martin Garwood; NHPA

Hot-blooded Bees

Quick to warm up, these solitary insects thrive in the chilly British spring

by Graham N. Stone

On cold, cloudy days early in the British spring, very few insects forage for nectar and pollen despite an abundance of flowers. A few queen bumblebees, the first of the year, might be out, but they are flying slowly through gardens in search of nesting sites. Honey bees stay huddled in their hives. They emerge only when the sun comes out and warms the air to 50° F or more. If the sky clouds over, the honey bees vanish.

One species of bee, however, thrives here in the early spring. About twice the size of a honey bee, *Anthophora plumipes* is Britain's most common species of "flower bee," so named because males in the genus *Anthophora* are sometimes found sleeping in flowers. This genus of solitary bees, which make tunnels in walls of earth or soft rock, is found throughout the Northern Hemisphere. When I first observed *A. plumipes* flying from blossom to blossom at temperatures as low as 32° F, I realized they must possess some impressive physiological adaptations to cold. Most small bees and other insects lose heat too rapidly for their flight muscles to function efficiently in cold weather. Yet flower bees mate, provide for their young, and die before mid-June. They complete their life cycle in the notoriously unreliable British spring, which, although it has its relatively warm days, also has its long periods of cold, rainy weather and sharp frosts. I de-

The stone and mortar wall, below, that separates University College and Merton College at Oxford University is a nesting site for hundreds of female flower bees. Right: At night and in cold weather, males may huddle in unused tunnels in the same wall.

Both photographs by Graham N. Stone



cided to study how these bees overcame the limitation of the cold.

The courtship and mating behaviors of *A. plumipes* were my second reason for studying the species. Males compete fiercely for opportunities to mate, often fighting each other in flight. Sometimes a group of males will pursue a single female, forming a long "queue." Little else was known about their mating rituals.

A parking lot in the center of Oxford hardly seems like an ideal site for studying nature, but despite the noisy traffic and the exhaust fumes, this is where I spent three years studying flower bee ecology and behavior. The parking lot is surrounded by quiet college gardens and quads, where the bees forage among early-blooming spring flowers. At the rear of the parking lot, a stone and mortar wall at least three hundred years old separates University College from Merton College. The southern side of the wall is pocked with holes about a half inch in diameter, each one an entrance to a flower bee's nesting tunnel.

For up to fifteen hours each day, I watched the comings and goings of the bees, gradually gaining insights into their behavior. Sitting on a deck chair in a space between cars, gazing intently at an apparently unremarkable piece of wall in the car park, I came to be regarded as some sort of benign lunatic. Amazingly, over all the years that I watched bees in the parking lot, only a few people ever asked me what I was doing there. Oxford must be one of the few places in the world where my odd behavior could have gone unquestioned.

The male flower bees I studied are rust-brown in color, while the females are black. Both sexes are extremely furry and closely resemble bumblebees when at rest. This similarity soon disappears when the insects fly. Flower bees, particularly the males, are superb aerial acrobats, capable of hovering with pinpoint accuracy for long periods or executing tight turns at high speeds. Their visual acuity is also impressive. I have watched them hover within an inch of an orb-weaving spider, examining the motionless predator from both sides of its web before flying on. They are most sensitive to movement and respond to it by disappearing, a behavior that has given them a reputation for shyness. Only by remaining absolutely still, could I observe them up close without disturbing them.

Before dawn on a cold day in March 1987, I arrived at the parking lot to make my first formal observations. The bees overwinter as pupae, and males emerge before the females, sometimes as early as late February if the winter has been mild. Establishing territories in fields and flower gardens, males prepare to compete for the





females, which emerge from mid-March onward. Females select the nest site (in this case the wall) where they excavate the tunnels and brood cells.

On my first morning of observation, the temperature was hovering around a distinctly chilly 40° F. I parked my deck chair in an empty space between cars, poured some coffee from my thermos, and waited. Within a few minutes the first female emerged from her tunnel in the wall. Although it was too dark to see well, I could hear her flying slowly back and forth in front of the nest before disappearing in the direction of the Botanical Gardens, half a mile to the east, in search of pollen and nectar. The bees frequently perform such side-to-side flights outside nest entrances to orient themselves to marks on the wall, which they use to guide them home on their return. Over a period of thirty minutes, all the females left their tunnels, the last disappearing toward University College as the clock in nearby Magdalen College struck 5:30. My hands were numb. How were these bees able to move?

Most insects rely on the sun's warmth to raise their body temperatures high enough for flight, and when temperatures fall too low, they become sluggish. But researchers are finding a growing number of insects that are endothermic; that is, they are able to generate their own heat.

Bumblebees are among the best-known endothermic insects, thanks largely to twenty years of work by Bernd Heinrich, a biologist currently at the University of Vermont. He and other researchers found that flight muscles of bumblebees and some other insects are among the most metabolically active tissues known, burning oxygen at a very high rate. In the process, only 15 to 20 percent of the chemical energy consumed is converted into wing movement; the considerable remainder is released as heat and is potentially available to the body. In cold weather, endothermic bees precede each flight with a warm-up period, using flight muscles to raise their body temperature. (The bee's flight muscles are powered by a number of interdependent chemical reactions. The various enzymes that control these reactions work efficiently only in a narrow range of relatively high temperatures. *A. plumipes* cannot fly well with thoracic temperatures much below 77° F.) The warm-up process closely resembles shivering in mammals: the sets of muscles that raise and lower the wings contract more or less simultaneously, causing the wings to vibrate. Once the thorax reaches the required temperature, the insect begins contracting the two sets of muscles alternately, moving the wings to provide the lift for takeoff. The exertion during flight maintains the high temperatures. Bumblebees, for instance, can forage at air temperatures as low as 32° F, while maintaining a thoracic temperature in excess of 86° F.

I caught a few of the Oxford bees to take to the laboratory so that I could determine whether or not they were endothermic. Taking the temperature of such a small animal without harming it is not easy, but it can be done. With great care I surgically inserted a tiny sensor into the bee's thorax, placing it in direct contact

ile a female flower bee forages for nectar and pollen, left, two les looking for a chance to mate hover behind her. Below: A ale sips nectar from a lungwort blossom.

n Garwood; NHPA



th the heat-producing machinery. I at-ched the wire leading from the sensor in e bee's body to a measuring device in ch a way that the animal could walk, ed, and take off unhindered. At the end the experiment, the sensor was removed d the bee was released unharmed. ower bees, I discovered, are astound-gly endothermic for their size, particu-ly females, which can raise their tho-cic temperatures as much as 35° F per inute. The lower the air temperature, wever, the lower the rate of increase. At air temperature of 48° F, for instance, es may take about ten minutes to warm flight temperature. Nevertheless, their vels of heat production are about one d a half times those of larger bumble-es under the same conditions.

Measurements that I have taken from venty-six species of *Anthophora* in ritain and Israel show that this group arms up fastest. The record-holding spe-es is *A. fulvitarsis,* which is slightly rger than *A. plumipes* and flies in the illy spring mornings in the Negev esert in Israel. Perhaps the flower bee's perior heating system evolved in the esert regions of the Middle East and Cen-al Asia, where such bees are found in eir greatest diversity. Arid-zone bees are dapted to fly in low temperatures—only the cold, early morning hours can desert flowers spare enough water for their nectar to flow.

However it evolved, the ability to heat up rapidly definitely enables *Anthophora* bees to fly with speed and precision at low air temperatures. For a solitary wall-nesting bee in the temperate zone, aerial agility can mean the difference between life and death. Early in the morning, on top of the wall in the college parking lot, birds wait for the female flower bees to emerge. But a female leaving her nest is too quick to be caught. Returning laden with pollen and nectar, however, she is vulnerable for the few seconds that she takes to align herself with familiar features on the wall before flying into her tunnel. Great tits and blue tits seize such opportunities to swoop down and catch bees. But their intended quarry often darts sideways at incredible speed, and even though the birds have only a few feet to dive, they almost always return to their perches with empty beaks. Male bees are equally fast. I have filmed aerial jousts between male flower bees and have recorded them making ninety-degree turns in flight in a twenty-fifth of a second—usually fast enough to save their lives from any aerial predator.

On warm mornings, male flower bees leave the wall shortly after the females depart, but on cold days, males may stay in their tunnels for as much as two hours after the females have gone off to forage. Once out, males guard their territories and look for mates. The females work a long shift; they often forage until as late as 9:00 P.M., completing twenty to twenty-five round trips in search of pollen and nectar. Foraging continues when low temperatures keep most bumblebees and honey bees in their nests. Even rain does not stop the flower bees from flying. And when foraging ceases at night, females may continue to work within the wall, excavating new brood cells along the sides of the tunnel at a rate of about one a day. By placing my ear at the entrance of a nest, I could often hear the scraping sounds of a female's mandibles as she bit into the rock or mortar. Every few minutes, she would back up to the entrance and jettison a small load of rubble.

Once a cell is excavated, the female lines it with a layer of fine silt, tamping it down with a smooth plate at the tip of her abdomen. She then lines the cell with a glandular secretion to stop mold from spoiling the food she stores inside. The cell is now ready for provisioning with pollen and nectar and then for a single egg. Unlike social bees, solitary flower bees lack nestmates to help feed the developing larvae, so females must be completely self-sufficient in providing for their young.

Despite the impressive heat-generating abilities of this bee, the payload they can carry when foraging is still strongly dependent on air temperature. At 53° F and below, most females collect only nectar, carrying an average load of 21.5 milligrams per trip. During warm weather, however, females will carry up to 71 milligrams of both pollen and nectar, or more than a third of their body weight.

As they forage, female flower bees must put up with the aggressive attentions of courting males, which are hot-blooded in more than one sense of the word. In their small territories around patches of flowering plants, such as comfrey and lungwort, males intercept other males that attempt to enter. If an intruding male does not depart immediately, the two grapple in flight and drop to the ground, where they continue to

A male Anthophora plumipes *rests on an aloe plant. The feathery hairs on its middle pair of legs account for its specific name, which means "feather-footed" in Latin.*
Graham N. Stone

fight it out (completely oblivious to the huge human observer only a few inches away). Eventually, one male—almost always the smaller of the pair—flies off, with the victor in pursuit.

The number of females that visit a male's territory depends on the quality and quantity of its flowers. In the early spring competition for the best patch of flowers, the larger males are usually able to repel others from prime territories and are thus better placed to encounter foraging females. Although aggressive toward each other during the day, males commonly roost together in nest tunnels in the wall at night or in particularly bad weather. One threesome that I observed shared the same shallow nest entrance for ten weeks.

Males usually rest in a sunny spot in their territory and chase after anything even vaguely resembling a female flower bee. Predominantly black bumblebees are the most common targets of this misguided passion, but blackbirds, and even black cats, are sometimes pursued. The stimulus provided by a female is so strong that when she flies by, all territorial dispute is abandoned in favor of pursuing a potential mate, wherever she flies.

Males show a characteristic flight pattern when they approach a female, hovering approximately two to four inches behind her as she moves from flower to flower. Often the male follows her every move for a minute or more, trying to keep her in sight. The female is swift and often disappears, but if the male is able to follow her, he darts rapidly forward and grasps her around the waist with his legs. The pair then fall to the ground, where the female usually rejects the male by curving her abdomen beneath her body and fending him off with her legs and mandibles. Although she struggles and buzzes vigorously, the male is never stung.

When the female is receptive, she allows the male to initiate a complex courtship. The species' name *plumipes* (Latin for "feather-footed") describes the male bee's second pair of legs, which end in a brush of long, featherlike hairs. The male draws one brush and then the other through his jaws, coating them with pheromones secreted by special glands in his head. He waves these feathery, scented feet alternately back and forth in front of the female's head while they mate.

If other males discover the pair on the ground, they will usually try to dislodge the mating male. Watching slow motion video recordings of these attacks, I saw male bees flying into a pair, trying to pull the mating male away with their legs and mandibles. Even if an attacker is successful, the female always has the last word and can always reject a new male.

Males of other solitary bee species live much shorter lives than females, so that all mating takes place in the brief period when females emerge at the start of the season. Male flower bees, however, live longer than females, and this seems to be consistent with the species' mating season, which lasts all spring. This raises the question of whether female *A. plumipes* mate more than once during their lives. While DNA "fingerprinting" of the sperm carried by individual females has not yet been done, work by Morteza Esmaili in the 1960s showed that the volume of sperm carried by females of a North American species, *A. occidentalis,* varies considerably, suggesting that females do indeed mate more than once. Another explanation for the extended mating season may be that females emerge at different times from place to place, so that virgin females continue to appear throughout the spring. I noticed that after the first week at a given nest site, receptive females make up only a small proportion of the resident females.

As each female forages, she has to run the gauntlet of a crowd of males. I often saw a female race by with a train of six or seven males flying behind her. Flower bees fly so fast that it was often impossible for me to see exactly what was happening. I managed to persuade two other Oxford zoologists, Tim Blackburn and Phil Loader, to help me catch the mating melee on video. To recognize individuals, we marked and weighed as many males as we could catch with small, colored, numbered plastic discs placed on the top of the thorax. On frame-by-frame replays, we observed the male bees as they hovered in their queue. When we disrupted the line of males, they dispersed and then returned resuming the same order. This suggests that males are able to recognize where they belong in line. Furthermore, the order of males in the train is not random; their distance from the female is in order of decreasing body mass, suggesting that size plays an important role in mating.

Female flower bees are harassed not only in flight; a female on an exposed flower may be leaped upon by a succession of males at a rate of one every two to three seconds. This level of interference severely hampers her foraging, and females occasionally appear to decide that enough is enough. They will then chase males away, even giving some of them a head butt in flight until they disperse.

When levels of male interference are at their highest—in the middle of the day—females tend to stay low. In the dense mesh of stems and leaves, a female can continue to forage, but at a price. She must spend more time flying from flower to flower because there are fewer blooms lower down on the plants. These inner flowers contain significantly less sugar than outer flowers so females are moving into a less rewarding environment. In the absence of interfering males, however, females spend less time fighting off suitors and more collecting nectar and pollen.

What would females do if these interfering males were removed? In a simple series of experiments, I captured all of the males from a patch of flowers and confined them to a large netting cage over some potted lungwort. The females now preferred to forage from the more productive outer flowers and largely ignored the more labor-intensive inner flowers. The males were released the following day, and the females once again adopted their evasive strategy during the peak period of male activity. Flower bees prove what some have maintained for a long time—females get on with the important business in life far more effectively without the interference of hot-blooded males! □





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The Right and the Sinister

Fossils reveal that handedness has at least a 500-million-year history

by Loren E. Babcock

One notable sidelight of the 1992 presidential election in the United States was that the three main candidates were left-handed. Had Bill Clinton, George Bush, and Ross Perot all been right-handed, their directional bias would have attracted no attention. Yet because only about one in ten persons is left-handed, the odds against three southpaws all seeking the job are only about 1 in 1,000. (Of forty-one American presidents who took the oath of office prior to 1993, only four—James Garfield, Harry Truman, Gerald Ford, and George Bush—demonstrated a strong preference for using the left hand.) Words and phrases that originally stem from an awareness of handedness—words such as *dexterity, adroit, sinister, gauche,* and *right-hand man*—abound in Western languages, suggesting a deeply rooted fascination with human handedness. Unfortunately, the connotations of terms such as *gauche* and *sinister* (which derive from "left") put left-handers in an awkward or even unsavory light; they are outside the norm. In addition, many artifacts of our modern culture, ranging from doorknobs and scissors to gearshifts and computer keyboards, are designed and manufactured with little regard for the lefty minority among us.

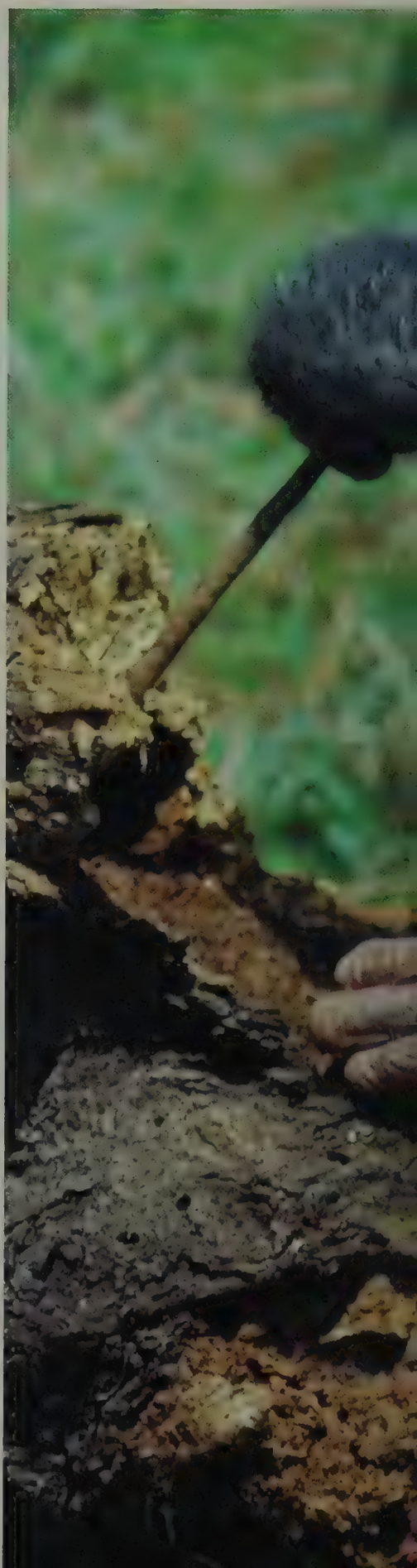
Until about twenty years ago, many anthropologists, biologists, and cognitive scientists took for granted the notion that humans were distinct from the rest of the animal kingdom by virtue of what is called behavioral lateralization, or behavioral asymmetry—the tendency to favor one hand (or foot or eye) over the other for certain tasks. In the mid-1800s, the French physicians Paul Broca and Marc Dax showed that handedness was related to the division of the brain into two hemispheres, each of which oversees or is dominant for certain functions. More than a century of research on humans has firmly established the link between the brain's hemispheres and physical actions such as throwing, kicking, and writing. Despite many anecdotal accounts of handedness among nonhuman animals, few researchers, until quite recently, advocated the view that animals, too, display definite right–left behavioral differences. Growing evidence suggests that such differences are common among animals, and the expression of right–left biases in numerous and distantly related species implies that these differences have had a long evolutionary history. But just how long has handedness been around?

Archeological records—paintings, drawings, and carvings of humans engaged in activities involving the use of hands—indicate that humans have been predominantly right-handed for more than 5,000 years. In ancient Egyptian artwork, for example, the right hand is depicted as the dominant one in about 90 percent of examples. Fracture or wear patterns on tools also indicate that a majority of ancient people were right-handed.

Cro-Magnon cave paintings some 27,000 years old commonly show outlines of human hands made by placing one hand against the cave wall and applying paint with the other hand. Children today make similar outlines of their hands with crayons on paper. With few exceptions, left hands of Cro-Magnons are displayed on cave walls, indicating that the paintings were usually done by right-handers.

Anthropological evidence pushes the record of handedness in early human ancestors back to at least 1.4 million years ago. One important line of evidence comes from flaking patterns of stone cores used in toolmaking: implements flaked with a clockwise motion (indicating a right-handed toolmaker) can be distinguished from those flaked with a counterclockwise rotation (indicating a left-handed toolmaker).

Even scratches found on fossil human teeth offer clues. Ancient humans are thought to have cut meat into strips by holding it between their teeth and slicing it with stone knives, as do the present-day Inuit of Greenland. Occasionally the knives slip and leave scratches on the users' teeth. Scratches made with a left-to-right stroke direction (by right-handers) are more common than scratches in the opposite direction (made by left-handers).

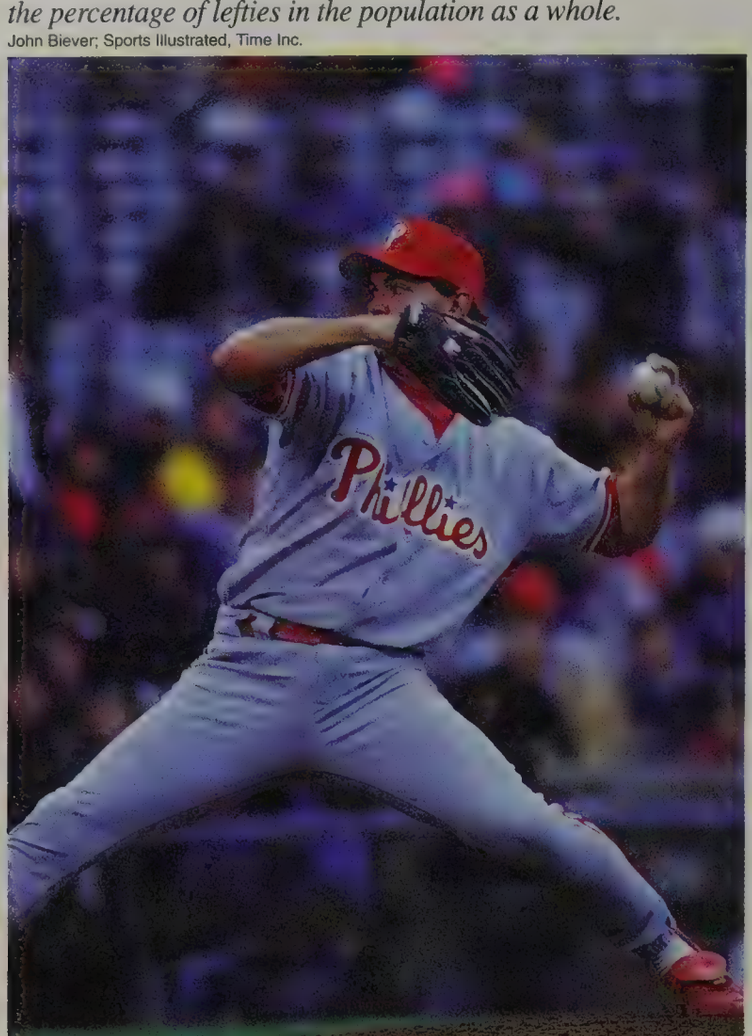




A young female chimpanzee in Kenya uses her right hand to manipulate a stick while digging for termites.
Peter Davey

Like some 90 percent of humans, pitcher Kip Gross, below, right, is right-handed. But many left-handers, such as Terry Mulholland, below, left, display athletic prowess. In major league baseball, the percentage of southpaw pitchers exceeds the percentage of lefties in the population as a whole.

John Biever; Sports Illustrated, Time Inc.



Ronald C. Modra; Sports Illustrated, Time Inc



Still other evidence comes from cranial morphology: scientists think that physical differences between the right and left sides of the interior of the skull indicate subtle physical differences between the two sides of the brain. The variation between the hemispheres corresponds to which side of the body is used to perform specific activities. Such studies, as well as studies of tool use, indicate that right- or left-sided dominance is not exclusive to modern *Homo sapiens*. Populations of Neanderthals and much earlier members of our genus, such as *Homo erectus* and *Homo habilis*, seem to have been predominantly right-handed, as we are.

In addition, many living monkeys and apes seem to be left-hand dominant when reaching for food or other objects, but right-hand dominant when manipulating objects. For example, chimpanzees, when using sticks to excavate for termites, preferentially use one of their hands, commonly the right. The tendency of human females to carry their babies in their left arms (whereas men tend to carry babies in their right arms) may have deep evolutionary roots: female chimpanzees, gorillas, and orangutans also carry their babies in their left arms.

Even among nonprimates, both living and extinct, asymmetry of body parts may be related to patterns of behavior. The asymmetrical tusks of Pleistocene, or Ice Age, elephants; the asymmetrical, paired teeth in some worms; and the asymmetrical, hard mouth structures of the extinct eellike conodonts may reflect a tendency of these animals to favor one side while gathering food. Similarly, in crustaceans such as lobsters, one claw is often larger than the other (although lobsters can conveniently switch their handedness if a claw is lost). In invertebrates, spirally shaped shells or other hard parts, which are perhaps related to behavioral asymmetry, are found in numerous species, including sea lilies, corals, and such mollusks as snails, clams, and oysters.

Fruitful sources of information about animal behavior are trace fossils, such as tracks, trails, burrows, borings, and bite marks, which are records of animal activity. Recently, trace fossils have been stud-

in attempts to establish whether prehis-
ic animals had any right–left biases in
ir behavior. Spiral burrows uncovered
Miocene rocks, some 5 to 23 million
ars old, in the midwestern United States
ow that the beavers that constructed the
rrows consistently used either right- or
t-sided strokes of their chisellike front
th. Although individual burrows spi-
ed either clockwise or counterclock-
se, the total number of burrows going in
ch direction was about equal. Trace fos-
s have revealed many other examples of
iral coiling, indicating that asymmetri-
l behavior was common among extinct
eatures, just as it is among living ones.

The best-documented and oldest ex-
mple of behavioral "handedness" among
ssil animals comes from healed injuries,
rticularly scars left by predators, pre-
rved on trilobites more than 500 million
ars old. A group of extinct marine
thropods, trilobites are distantly related
present-day crustaceans and horseshoe
abs. Richard A. Robison, of the Univer-
y of Kansas, and I recently studied
aled injuries on trilobite fossils. We
ere able to distinguish healed injuries
om other kinds of malformations—ge-
tic or embryological abnormalities and
vellings due to disease or parasitism—
cause injuries are characterized by obvi-
s physical breaks in the trilobites' crusty
koskeletons that have subsequently
aled, usually by "callusing" over. Trilo-
tes with such healed injuries are there-
re the ones that survived injury and lived
tell the tale as fossils. (We cannot iden-
y fatal injuries caused by predation be-
use they lack signs of repair and can re-
emble breaks made after death by
cavengers or by physical forces that
oved and damaged the carcasses.)

Healed injuries of trilobites are of two
pes: those caused by predators (primar-
y bites from mouths and pinches from
aws or grasping appendages), and those
ue to accidental injuries incurred during
olting, copulation, or combat. In our
ilobite study, Robison and I attributed in-
ries to unsuccessful predation only if
ey were located on a part of the body that

Parrots, such as the African gray, below, usually pick up objects and food with the left foot.
Stephen Dalton; NHPA





A 425-million-year-old trilobite, Arctinurus boltoni, *right, bears the scar of a bite on the right side of its rear end. This 3¼-inch-long invertebrate survived the attack, which removed about eight legs and a chunk of its crusty exoskeleton.*
Loren Babcock

was unlikely to have been accidentally broken, if they covered a large part of the body, and if they were not just simple breaks that might be expected from an accident. We discovered that injuries due to accidents occur randomly on trilobite remains, but injuries due to predation do not. Scars left by the teeth and claws of predators are most common near the edges, on the rear, and on the right side of a trilobite.

What creatures in Paleozoic seas preyed upon trilobites? One predator frequently implicated is *Anomalocaris,* which was first described from fossils of the Burgess Shale in British Columbia. This animal hunted trilobites during the Early to Middle Cambrian period, some 570 to 517 million years ago (*see* "Terror of the Trilobites," *Natural History,* December 1985). An important piece of circumstantial evidence for this link is that the size and shape of many bite marks on trilobites from this site and time match the size and shape of the circular, nutcracker-like mouthparts of *Anomalocaris*. Also, many North American fossil-bearing rocks of Cambrian age that contain bitten trilobites also contain the remains of *Anomalocaris,* further supporting the idea that at twenty inches long, this carnivore was one of the major predators of trilobites of its time.

But *Anomalocaris* was not the sole scourge of Cambrian trilobites. Broken plates of trilobite exoskeletons have been found in the gut contents of other arthropod fossils from the Burgess Shale and from Utah. Early forms of chelicerates (relatives of the horseshoe crab) and crustaceans (relatives of shrimps, crabs, and lobsters) also preyed on trilobites. After the Cambrian and before the end of the Paleozoic era (when trilobites became extinct), various fishes, cephalopods, and arthropods probably preyed on trilobites.

Several Cambrian trilobites and the Ordovician trilobite *Isotelus* (the state invertebrate fossil of Ohio), may have been predators in their own right or even cannibals. All trilobites had a large, usually calcified plate, known as a labrum, in front of and on the underside of the mouth. But unlike those of most other trilobites, the labrum of *Isotelus* was fork shaped and equipped with beveled, sharp, and serrated edges, remarkably similar to the cutting surface of a steak knife or a miniature tooth of the dinosaur *Tyrannosaurus rex.*

Why are most predation scars preserved on the edges, right side, and rear end of trilobites? Most vital organs—such as the brain, nerve cord, and parts of the digestive and circulatory systems—of trilobites lie in an elongate, raised section called the axial lobe, which runs down the middle of the body. Any substantial injury to the axial lobe probably would have been fatal, and the trilobite therefore would not have joined our sample of fossil specimens. In contrast, the pleural lobes, which run down either side of the axial lobe, house a few vital organs, but wounds to these areas seem to have healed readily.

Of trilobites showing predation scars, approximately 70 percent have injuries confined to the right side. Provided that a sufficiently large sample is collected, this pattern holds true whether one analyzes all

Male fiddler crabs, below, use their small cutter claw to stabilize prey and the large crusher claw to break the prey's hard shell. The ratio of right to left crusher claws is roughly 50:50.

Both photographs by John Shaw; Bruce Coleman, Inc.





ilobites, trilobites of a single time period, even trilobites found within a single ock formation. This asymmetry in scarng cannot be attributed to the presence of n unpaired vital organ on the body's left de, which, if breached, would have reulted in the death of the victim. Beautilly preserved trilobites collected from tes as far-flung as China, British Columia, Utah, New York State, and Germany now that all of the vital organs contained the pleural lobes were paired.

We also find more nonlethal predation cars on the rear end of trilobites than on ne head, which contains the brain, stomch, and other organs. In fleeing from a ursuing predator, a trilobite probably eered to one side to protect its head. On uch a moving target, the tail shield, or pyidium, was the body part most susceptble to attack but the part least likely to ustain a deadly bite.

The strong lateral asymmetry of predaon scars is most likely due to handedness n either the predators or the trilobites or erhaps in both. Today, many animal speies or populations seem to have stable atterns of asymmetrical behavior; extinct reatures probably possessed similar beavioral biases. Because of differences in he expression of handedness among varius groups of animals, however, not all of hose patterns are likely to have been inerited through a common ancestry. Rather, they probably arose at various imes as the result of similar ecological ressures exerted on distantly related anmals. The tendency for predation scars to e on the right side of trilobites suggests hat the predators, at least the less successful ones whose "misses" we study, preferred to attack or bite on that side first. If iting were the mode of attack, surely hose predators deserved to be considered sinister, for they tended to bite from the eft side of the mouth.

Also possible is that a fleeing trilobite had a stereotyped escape maneuver that included swerving in a particular direction. Such turning may have consistently exposed one side of the body to attack. A combination is also possible—one-sided evasion by the prey and one-sided attack by the predator. Predators may have learned to anticipate the escape behavior of individuals belonging to favorite prey species and then honed their attack strategies to compensate for it. This may partly account for one of the most curious aspects of handedness: despite the predominance of a directional bias in some species, a certain percentage of individuals deviate from the norm, thus insuring that some individuals of the species will survive, even if predators have figured out the general pattern of escape.

When considering the evolutionary history of handedness, the question of heritability arises. Is handedness inherited? It must be to some extent; otherwise, species would not maintain similar proportions of right- and left-handed individuals through



The shells of Cuban tree snails reveal a natural asymmetry in their rightward spiraling; left-coiling shells are rare.
James Carmichael, Jr.; NHPA

numerous, successive generations. That the same proportion of right- and left-handed individuals would crop up randomly time after time is certainly unlikely. Studies suggest that left-handedness does tend to run in human families. More than 90 percent of children born to right-handed parents are themselves right-handed. Where one parent is left-handed, the proportion of right-handers drops to about 80 percent. And if both parents are left-handed, that proportion drops to about 75 percent.

Present evidence indicates that handedness can be inherited in a least two ways. The first, which is shown by the "handedness" of the mouths of cichlid fishes from East Africa's Lake Tanganyika, is by simple genetic recombination in which the normal pattern of Mendelian inheritance applies. Because these scale-eating fishes attack their prey from behind, right-sided cichlids snatch scales from the left side of their prey, whereas left-sided cichlids snatch scales from the right side. The ratio of right- and left-sided cichlids at any one time is influenced by the prey's alertness; the rarer type of cichlid (either right- or left-sided) is more successful at predation. If right-siders are rarer initially, their reproductive success increases and their population grows. Once the population becomes sufficiently large, however, the prey become more wary of right-siders, which means that the predatory advantage switches to the now rarer left-siders.

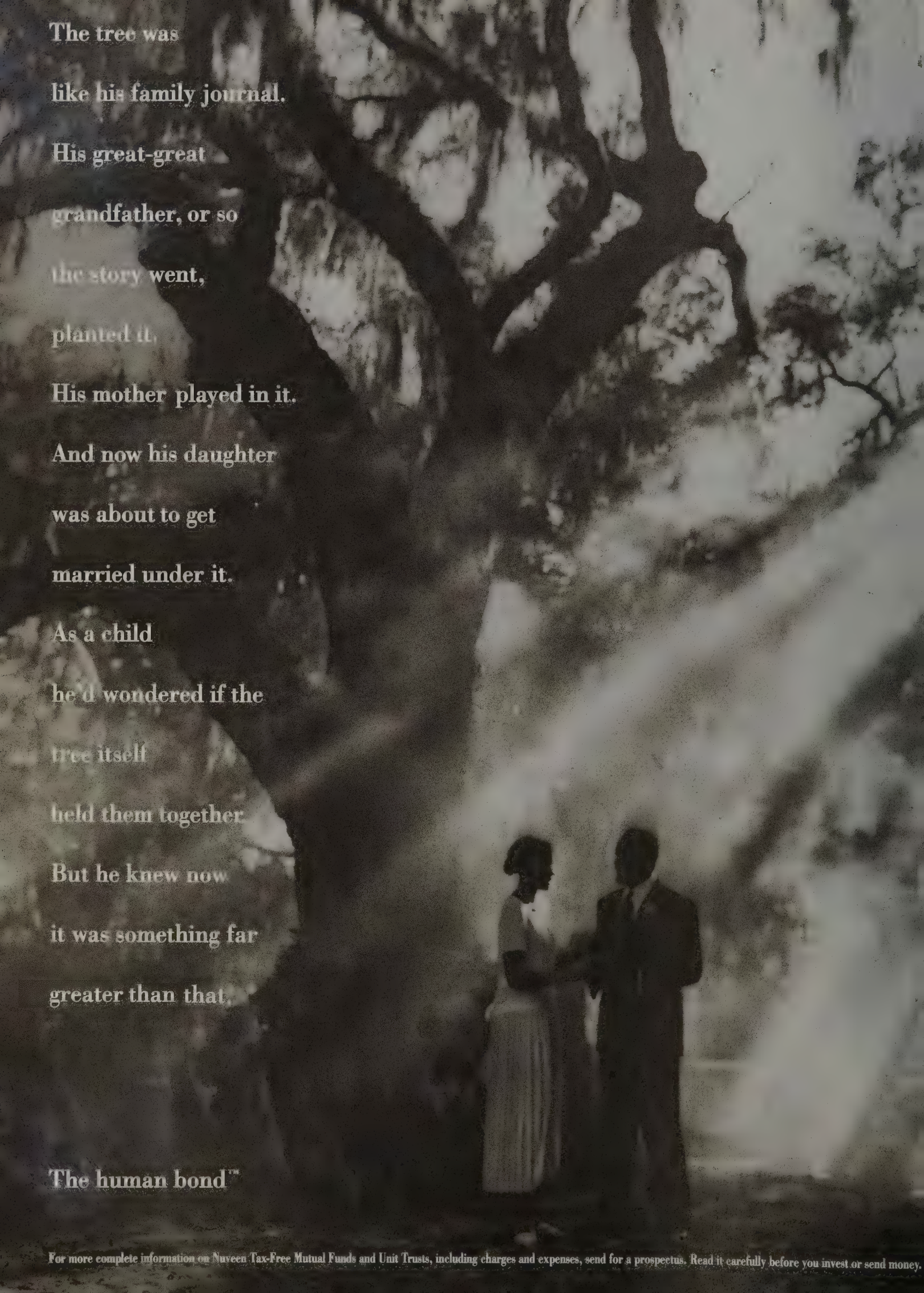
The second way of inheriting handedness is shown in some snails and single-celled ciliates. In these organisms, the direction of coiling or spiraling has been shown to be inherited in the structure of the cell and controlled by the mother's genes (not by the normal means of Mendelian inheritance). In this case, handedness is determined even before fertilization occurs.

Another question is whether handedness is adaptive; that is, does it confer some ecological or evolutionary advantage? The evidence—from the asymmetry of predation scars more than half a billion years old, and the occurrence of handedness or sidedness in organisms as diverse as animals, plants, bacteria, one-celled protists, and probably even fungi—suggests that it does. In humans, the species in which handedness has been studied most, correlations commonly have been made between hemispheres of the brain, hand dominance, and language development. In addition, a trend toward manipulating tools in a consistent way may result in greater skill and efficiency in their use. Finally, directed movement may not even be possible if an organism is perfectly symmetrical. Rather, one side must always take the lead. Which side leads may be irrelevant, but if one limb is stronger or used more consistently than the other for a particular activity, that limb will become the lead side. Even in ambidextrous individuals, one side must lead, although which side does the leading is inconsistent.

Quite possibly, handedness itself is not adaptive, but it may be linked to some other feature that is adaptive. Most snail species are predominantly coiled to the right, but right- and left-sided shells are not true mirror images of each other structurally. In some, shell shape and coiling direction of the internal organs seem to be independent, and the rarity of left-sided individuals is probably related to problems associated with trying to squeeze an animal whose internal structures are best suited to a right-coiled shell into a left-sided shell instead.

So, is it better to be right- or left-handed? Among humans, surely some disadvantages go along with being in the minority, to the extent that any tool constructed for use by a right-hander may be cumbersome for a left-hander to manipulate. Yet left-handedness can carry some distinct advantages; witness the disproportionately large number of gifted athletes, intellectuals, artists, and perhaps politicians—like the 1992 U.S. presidential candidates—who are left-handed. While no direct evolutionary advantage seems to accrue specifically to right- or left-dominance in any animal species over the long-term, an advantage does seem to be conferred merely by having a handedness. □





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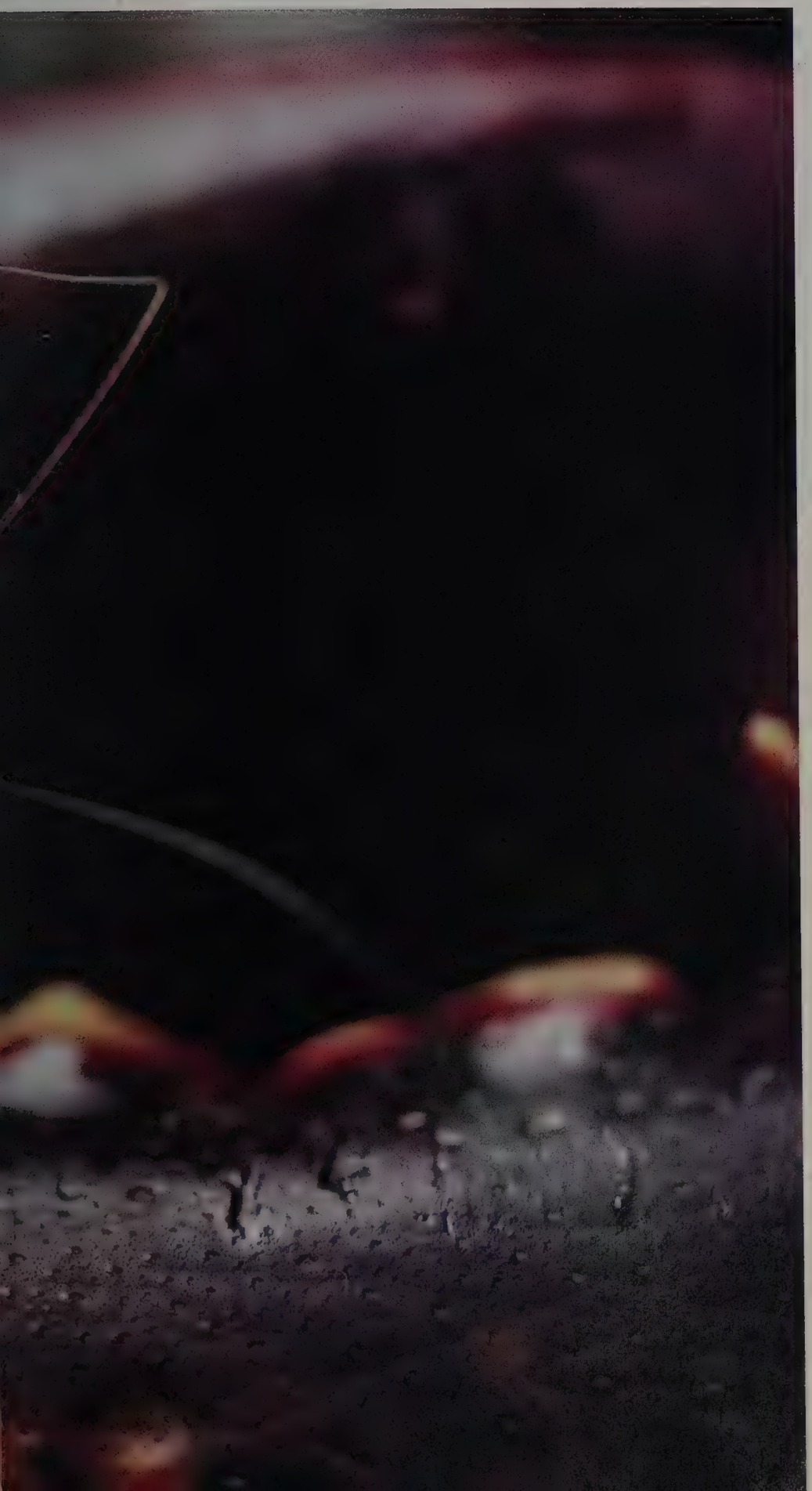
Just a few months old, this baby lobster may need another six years, and perhaps as many as twenty molts, before it reaches the size of the adult on whose claw it rests (where the photographer has placed it for contrast).
Bill Curtsinger



Gimme Shelter

For diminutive baby lobsters, the best start in life may be to head straight for a rocky retreat

by Richard A. Wahle



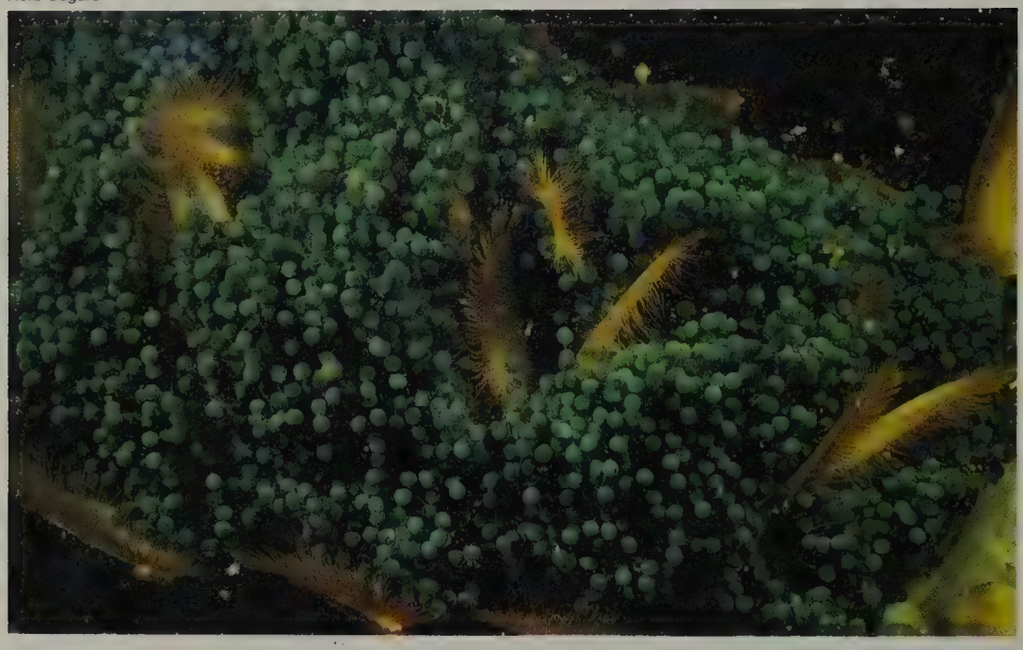
Almost universally, to be young means to be vulnerable and at risk. Once grown, most animals enjoy a measure of security and freedom unavailable to the small and weak. But the road from birth to adulthood can seem a long one, especially for those animals that start out tiny but—if they survive—mature into impressively large individuals. One of the most dramatic examples of a species with an immense range in body size through life is the American lobster. Hatching with a body weight of less than one-tenth of a gram, these lobsters can grow to a hefty ten kilograms (twenty-two pounds) or more, increasing their weight by a factor of 100,000. This would be comparable to a 5-pound newborn human growing into a 500,000-pound adult. Many large fish also have tiny larval beginnings, but lobsters are among the very few arthropods that start out so tiny and grow to such relatively gargantuan proportions.

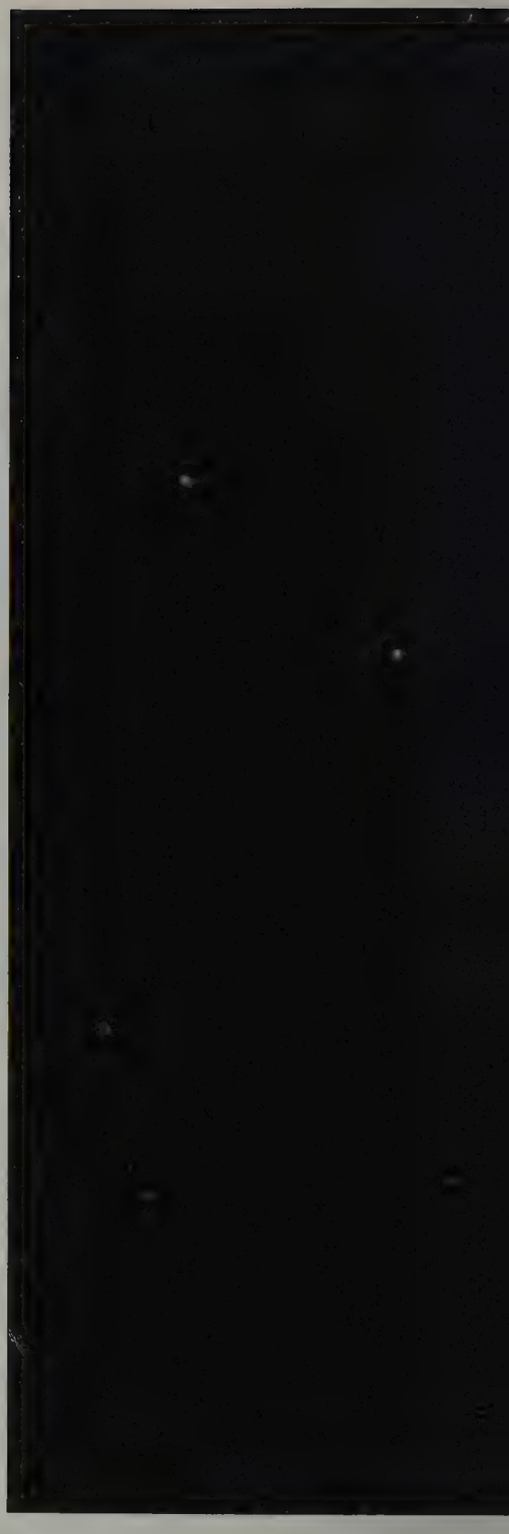
As lobsters grow, the changes in their size inevitably present them with different opportunities, as well as different risks, for body size is a crucial influence on many aspects of a creature's life, affecting where it can live and what it can eat, as well as what may eat it. I suppose I have been impressed by the significance of body size ever since—at age eight—I first confronted a "brontosaurus" at the American Museum of Natural History. Although that first impression was certainly less than intellectual, when the time came to choose a topic for my dissertation, I cannot help but think I was attracted to lobsters because of this great range in body size from birth to maturity (aside, that is, from more culinary interests).

Homarus americanus is an animal of great commercial and iconic significance. Lobstering is the largest single-species fishery in New England and the Canadian Maritime Provinces, and for many summer tourists, lobsters are nearly synonymous with the state of Maine. Because lobsters are so prized, I was not surprised to find that the species is tremendously well studied. Yet the whereabouts of the lobsters' nursery habitat and many details

A female broods her eggs, below, under her abdomen for eleven months. In late spring, the eggs hatch and begin a larval life adrift in the ocean. After a few weeks, they molt into tiny but recognizable lobsters, right, and use their feathery swimmerets to get about more actively in search of food.

Herb Segars





of their early life in the wild remained unknown. To complete our picture of this great arthropod's life cycle, I would first have to find its nursery ground. When I was a graduate student at the University of Maine, a research grant to my adviser, Bob Steneck, provided me with the financial and logistical support I needed.

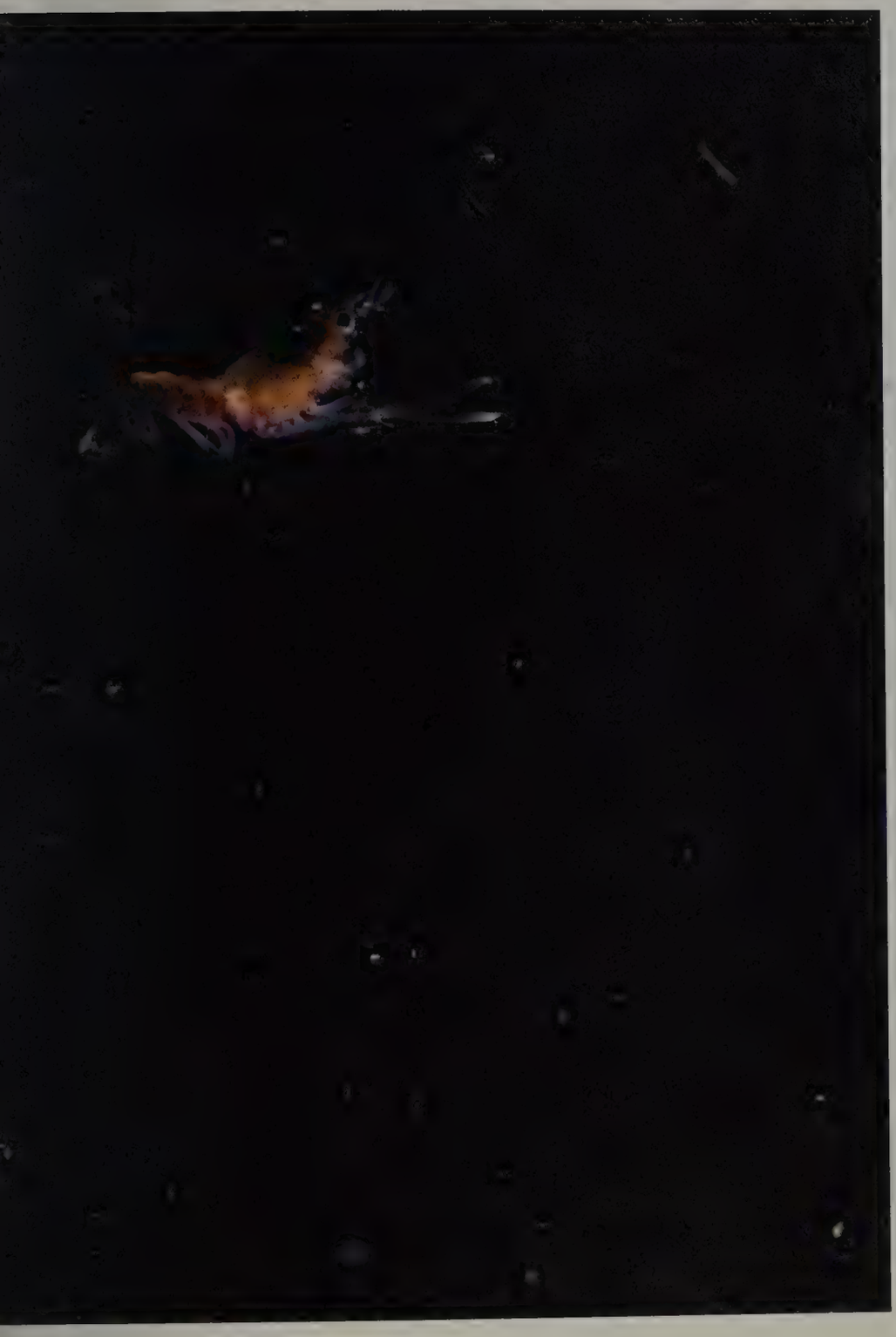
Like most marine animals that live on the sea floor, lobsters have a life cycle involving a free-swimming larval stage. (Why such a life cycle is so common is the subject of much debate, but it likely has to do with the greater evolutionary advantages in this environment of dispersing offspring over a large area as opposed to depositing them all in one place.) Lobster larvae, each about the size of a peppercorn, hatch from a brood of thousands of eggs carried by the mother under her abdomen (known to most lobster-meat fans as the tail). After hatching, they spend several weeks adrift in the sea, joining the countless other tiny plants and animals known as plankton. While waterborne, the larvae undergo three molts. Only with the final larval molt are they transformed into recognizable, if tiny, clawed lobsters, prepared to take up life on the sea bottom. By the time these thumbnail-sized postlarvae settle, they are likely to be scores of miles away from their place of birth.

Over the years, tag-and-recapture studies of harvestable lobsters (approximately one pound and up) caught in conventional traps have added greatly to our knowledge about the animals' movements and growth. For example, we now know that a mature female can travel as much as 180 miles (nearly the distance between New York and Boston) in a year. Such long-distance movements may be seasonal and related to an attraction to warm water, for we also know that lobsters grow faster and mature sooner in warmer water. Lobsters living south of Cape Cod mature within five or six years, whereas those in the perpetually cold Bay of Fundy may take as long as nine years.

But because lobster activity is temperature dependent, we cannot know from traps alone whether not catching lobsters in an area means no lobsters are there. The widespread use of scuba and submersibles since the 1960s has increasingly enabled researchers to study lobsters on their own turf. Now we can take a census of lobster populations and describe their behavior and habitats at the same level of detail field scientists enjoy while studying lions on the Serengeti. From these sorts of studies, we know, for example, that lobsters are nocturnal, foraging for crabs and mussels at night and hiding in shelters along rocks and kelp during the day.

Still, there remained a void in our knowledge about what lobsters do between the time they drop out of the plankton and the time they appear in traps several years later. Efforts to catch very young animals (especially individuals born that year) with traps and trawls failed, and as recently as the early 1980s, even divers sent down to look for them generally came up empty-handed.

Scientists were not completely in the dark about baby lobsters, however. Larvae drifting along near the sea surface can be scooped up with fine mesh nets and brought into the lab, where they do very well. State hatcheries, too, have for more than a century had success raising baby lobsters. Some laboratory studies have attempted to determine the kinds of habitats



Richard A. Wahle

postlarval lobsters might prefer to settle in. The results were ambiguous. Some of the experiments showed that when given a choice at the time of settlement, lobsters take shelter in preexisting structures (such as under rocks and inside shells, tires, or bottles) rather than dig a burrow in plain mud. Given no choice, however, lobsters proved themselves born burrowers. Small lobsters excavate U-shaped tubes, even galleries of tubes, which they then ventilate with their swimmerets, the small, feathery appendages under the abdomen.

As interesting as this behavioral flexibility is, it unfortunately did not help would-be field investigators narrow down likely nursery habitats. As a newcomer to the field in 1986, I was naïve in my approach to the problem and started diving to explore various sites. At that time, I received good advice from Richard Cooper, now with the National Undersea Research Center at the University of Connecticut, who in the early seventies had led some of the first diver surveys of lobster populations in Maine for the National Marine Fisheries Service. On a nautical chart, he pointed out several rocky sites along the Maine coast where his divers had consistently found small lobsters. Upon my own visits to those and other sites, I too found them, including some that looked small enough to have settled just that year. But each time I tried to dismantle the cobblestone matrix in which the little lobsters hid, the silt I stirred up blinded my efforts to get a good count. No wonder earlier attempts had been frustrated. I needed to devise a better way, but winter was closing in, and I would have to wait until the next summer.

By the summer of 1987, I was satisfied I had the solution, using what may best be described as an underwater vacuum cleaner. This device, familiar to professional divers, uses air from a scuba tank to create a suction current. Holding the mouth of the tube over the bottom, one diver can easily vacuum up small animals into a mesh bag as a partner moves the cobbles aside. Pleased with my success, I developed a system to take a census of what I saw as distinct habitats along the coast: sediment, cobble, bedrock, kelp beds, mussel beds, and eelgrass beds. Where I could, I examined these habitats at depths of fifteen and thirty feet.

After this first summer of intense sampling, the pattern was clear. The smallest lobsters were concentrated in habitats providing shelter, with the highest densities of young-of-the-year lobsters in shallow cobble habitats: nearly four per square yard. Including the older lobsters, which are found in larger shelters, as many as twenty lobsters have been found in the same square yard. We found lower densities in kelp beds, where the baby lobsters took shelter in the cobblelike clumps of mussels under the kelp. Bedrock surfaces were devoid of lobsters. And despite their ability to burrow in mud, no young-of-the-year were found in featureless sediment.

In the meantime, a Canadian colleague, Christiane Hudon, of the Department of Fisheries and Oceans Canada, had discovered, and published a paper on, a similar pattern in the Gulf of Saint Lawrence. Later, another marine ecologist, Ken Able, of Rutgers University, and co-workers uncovered small lobsters in crevices of old fiddler crab burrows in the thick peat that lines salt-marsh creeks on a Cape Cod estuary. To my surprise, none of us found new settlers in eelgrass beds, long regarded as prime nursery habitat for lobsters and other marine animals. (Even an



eelgrass bed into which more than 90,000 lobsterlings had been released over the preceding three years turned up nothing. Yet a cobble bed immediately adjacent to the stocked eelgrass had one of the densest baby lobster populations in the region.)

These findings began to complete the picture of the lobster life cycle. The youngest lobsters seem restricted to habitats that provide existing shelter, but once they have grown to about the size of a finger—usually in their second or third year—they are less restricted. Lobsters continue to use shelters throughout their lives, however, with only the larger ones venturing out in the open very frequently.

Since I knew from the earlier lab work that baby lobsters were good burrowers, I wondered why they were so restricted to habitats with ready-made shelter. Not surprisingly, the answer—or at least part of it—has a great deal to do with the risks of being so small. Traditionally, codfish were thought to be one of the biggest threats to young lobsters. One hundred years ago, Frances Herrick wrote in his classic treatise on the American lobster, "Next to man with his traps, the codfish is probably the most destructive enemy of the lobster…it takes in soft and hardshell animals alike up to eight inches or more in length." Herrick further describes a conversation with a Maine lobsterman who had cut open the stomach of a single large cod and found the remains of twenty-six lobsters inside.

In his book *Sea of Slaughter,* Farley Mowat quotes fisherman John Rowan's description of a 1896 excursion aboard "a schooner cod-fishing close to shore. They were fishing in about three fathoms of water and we could see the bottom actually paved with codfish. I caught a dozen in about fifteen minutes."

Unfortunately, in the waters off the coast of New England today, codfish populations are much smaller than in earlier times, and an experience such as John Rowan's is now unheard of. Plenty of evidence exists, however, that other fishes and crabs pose a threat to young lobsters. To test just how dangerous the little lobsters' environment is, I used underwater video cameras to document the fates of lobsters of various sizes that I had tethered



Bill Curtsinger

Once they settle to the bottom of the sea (or aquarium, in this case), the lobsters seek shelter, often under rocks, left. Mature lobsters move about in many types of habitats, including eelgrass, below, and can travel long distances.

Gilbert van Ryckevorsel; Seaphot Limited; Planet Earth Pictures



to the sea floor on monofilament leashes at a depth of about fifteen feet. In this way, I could record both the exact time a predator attacked and its identity. (The tethering deprived lobsters of a means of escape or shelter, but since all lobsters in the experiment were treated the same, I could get a relative measure of predation rates on lobsters of different sizes.)

In more than eighty-five hours of daytime remote-video monitoring, I recorded a variety of fish and crab predators but never a single cod. The most common were sculpin, well-camouflaged fish only a few inches long that lie motionlessly, stalk, and then pounce on their unsuspecting prey. Also common were juvenile cunner, the single species in the northern Gulf of Maine of a mostly tropical family of predatory fishes called wrasses. Collectively, these predators were quick to notice the newly arrived prey. Half of the smallest lobsters (those just ready to settle) were attacked within fifteen minutes of being placed on the bottom, and within forty-five minutes, half of the finger-sized lobsters were gone. In contrast, lobsters that had nearly reached harvestable size were never touched. The reason newly settled lobsters were never found burrowed in featureless mud quickly became clear: in spite of the lobsters' considerable abilities, burrow construction is time consuming and may take hours. In the wild, a new settler would more than likely be attacked before it could dig its way to safety.

The risk of being attacked declines sharply with size. Larger lobsters don't have to worry about small fishes and crabs, but they are not entirely free of predators. On offshore cruises with Bob Steneck's crew, for example, I have witnessed four-foot-long wolffish attacking one-pound lobsters and bringing them back to their lairs to consume. And all lobsters, no matter how big, are vulnerable for several days after molting until the new exoskeleton has hardened.

To examine whether lobsters of different sizes adjust their shelter use in response to predators, I designed a set of laboratory experiments. In these experiments, some of the lobsters were confronted with predators; others, in the control groups, were left undisturbed. I observed that when a sculpin was present, the smallest lobsters (those less than one inch long) rarely ventured out of their shelter, while lobsters in the corresponding control group spent a considerable amount of time exposed. In contrast, when sculpin were placed with some of the larger individuals, these lobsters spent as much time outside their shelters as did their control group and aggressively displayed their claws. This result paralleled earlier findings of the late neurobiologist Frederick Lang, who established the neurological basis for the fight-or-flight response in growing lobsters. Curiously, in my experiment, even hours after the predator had been removed, lobsters continued to behave as they had in the presence of a predator, whether their reaction was to display or hide. Were they at a heightened state of awareness after their encounter or were they still sensing the predator? To see, I ran another experiment, this time with only the smallest lobsters. I siphoned water from an aquarium that did have a predator into a lobster tank that had none and got the same result. Thus, lobsters are not only able to "smell" food, as every fisherman who baits a trap counts on, and as other research has demonstrated; they can also detect the odor of predators. And whereas one stimulus lures lobsters from their shelters, the other reverses that response.

But how do these conflicting stimuli affect a lobster's decision to stay sheltered or leave? Ample field and lab evidence suggests that lobsters forage away from their shelter and return to it with the food, as do nesting birds and squirrels. I have frequently seen piles of empty mussel shells at the opening of lobster shelters, evidence of previous meals. Peter Lawton, a behavioral ecologist, then at the State University of New York at Stony Brook, demonstrated experimentally that the hungrier juvenile lobsters are, the more time they tend to spend out foraging. Tracy MacKenzie, a

Herb Segars

Claws may make up nearly half an adult lobster's weight and are vital to the animal's ability to hold on to its shelter, right. If a display of claws does not settle a dispute between two adults, the encounter may get physical. In the conflict below, a lobster has pulled off the claw of its adversary. The claw will grow back, but only after several molts.

David Doubilet



graduate student at the University of Rhode Island, conducted further experiments—forcing some hungry lobsters to confront the complication of a predator nearby, while letting others build up an appetite in peace. She found that like many other animals, lobsters reduce their foraging time when there is a risk of being killed.

The results of these experiments, combined with the striking tendency of small lobsters in my experiments to seek shelter, suggested that the littlest individuals almost always opt for safety and that larger lobsters range more widely simply because they are less likely to be preyed upon. However, the story is more complicated than that, as the investigations of Boston University graduate students Diana Barshaw, Kari Lavalli, and Donald Bryant-Rich revealed. They found that in naturalistic lab setups, minus predators, newly settled lobsters managed to grow without ever leaving their shelters. These young lobsters must have subsisted on whatever food was available within their shelters. In separate experiments, they demonstrated that new settlers survive on a diet of suspended material, such as phytoplankton and zooplankton. These findings suggested, as an alternative to the predation-risk hypothesis, that the shift from a cryptic to a more wide-ranging life style may simply be determined by a growing need for more food.

For now, both explanations seem reasonable. As long as their food is essentially delivered to them, the tiniest lobsters may not need to make any trade-off between food and security. Eventually, however, they will need more food than happens to grow or float nearby, and they will have to begin making forays away from home. At this point, growing lobsters must weigh the dangers and benefits (perhaps perceived via chemical cues) associated with leaving in search of food.

If a lobster survives to maturity and manages to avoid a lobster trap, it may get impressively large. Lobsters, like many crustaceans and fishes, are indeterminate growers; that is, they just keep on growing throughout their lives. Greater size brings greater safety, increasing egg production, and competitive superiority, which enhance the chances of leaving offspring.

The largest lobster I have found on record was 42.4 pounds (my five-year-old son weighs 45 pounds). Lobsters have no growth rings to tell their age, but it is intriguing to speculate on the possible age of very big lobsters, which may be more than a hundred years old. But no matter how long a lobster lives, the first few moments after it settles on the sea floor may be the most critical of its life. □



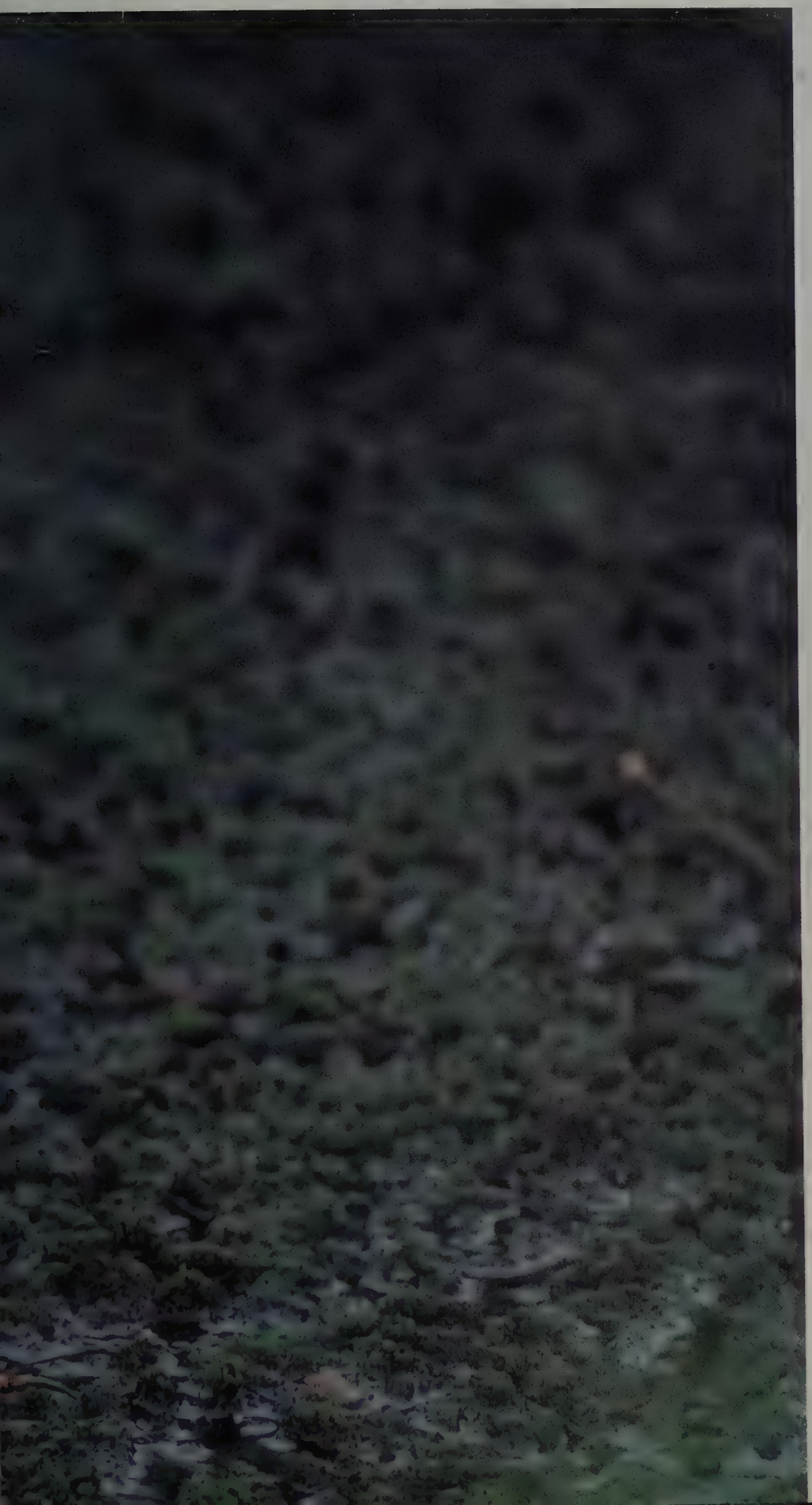
The typical strutting gait of the pukeko. The bird's large feet are well adapted for walking in a swampy environment and are used to hold grass shoots while feeding.
Geoff Moon



Inbreeding in the Marshes

For a New Zealand bird, incest is a small price to pay for safe offspring in a strong commune

by Ian Jamieson and John L. Craig



The line of five birds stopped when the front female crouched in a posture that signaled her sexual readiness. Her father, who was also her mother's father, then mounted her and they completed the act of copulation while the other birds—her mother, brother, and uncle—watched intently beside them. For a mating scene, it was exceptional. Not only were the coupling pair the closest of relatives but the other males did not fight or even jostle one another for the right to claim the female. The birds we were studying were pukeko, New Zealand's native gallinule, and for them it was a typical scene, one this group would repeat many times that day.

Unusual as their sexual behavior may be, pukeko themselves are not exotic or rare. Also known as swamphens—pukeko is their Maori name—they live in southern Europe, Africa, Asia, Australia, and on many islands in the Atlantic, Indian, and Pacific oceans. Long-legged, stout-bodied rails—closely resembling the purple gallinule of the United States Gulf Coast—swamphens are usually found in marshy habitats, where they habitually climb about in dense vegetation. They feed mainly on roots, seeds, and the shoots of grasses and leaves, and occasionally on small fish, frogs, and birds. Pukeko often eat parrot-fashion, holding long shoots with one foot while stripping off the outer layers with the beak to get at the tender pith within.

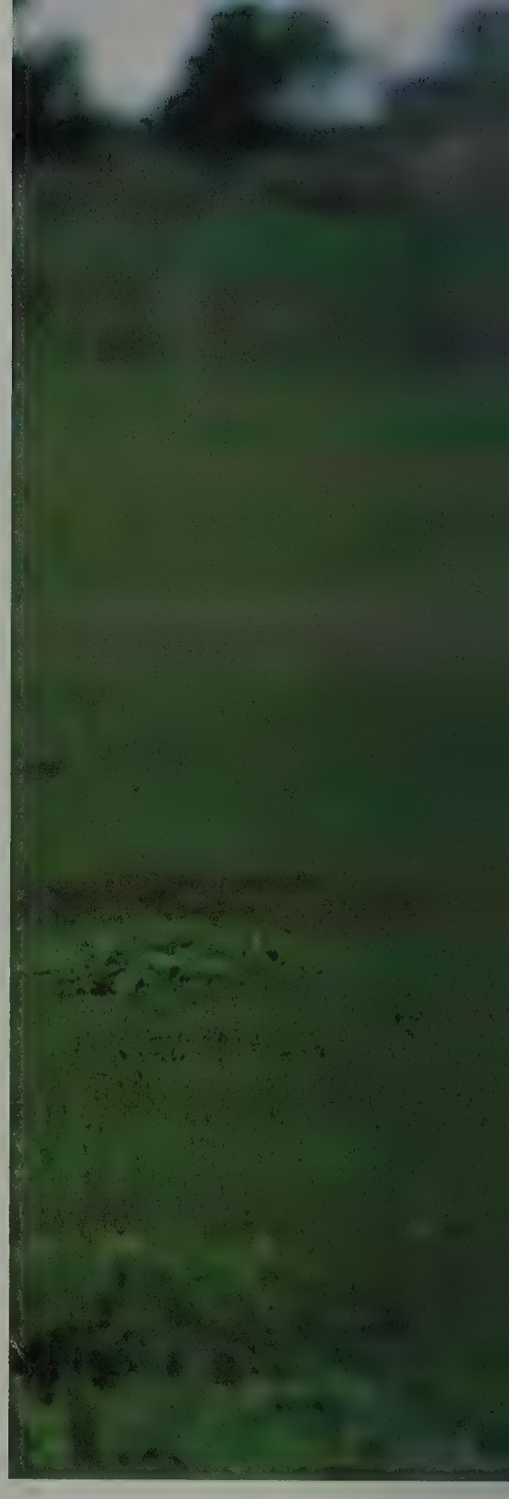
We were first drawn to study pukeko because they are communal breeders, a life style that seems to challenge classic Darwinian theories about competition and survival. Unlike most birds, which go off two-by-two to raise their young in separate territories, pukeko are part of a small avian minority (which includes acorn woodpeckers, dunnocks, and anis) that live and breed in social groups. In this arrangement, two or more males and one or two female breeders share a single nest. Several nonbreeding "helpers" may assist in rearing the young and in defending a common territory.

We wanted to find out why pukeko lived in communal groups and especially

To maintain social order, pukeko use an elaborate language of postures. The middle bird below is showing extreme submission to the higher-ranking group member on its left, which is approaching to defend its territory against the third bird, an intruding male. Right: When two birds from neighboring territories meet, they normally display to each other and turn away without incident. Occasionally, however, one will attack the other's back, kung fu fashion.

Both photographs by Peter Reese





why breeding birds seemed to tolerate sexual rivals. Luckily, pukeko are not difficult to observe. Unlike other rails, which are more often heard than seen, pukeko are fairly conspicuous. About twenty inches long from beak to tail, their large scarlet head shields and iridescent black-and-purple plumage stand out against the surrounding vegetation.

The species is usually found in swamps, bogs, or drains, but New Zealand pukeko are also commonly seen in open pastures adjacent to wetlands, being among the few native bird species whose populations soared with the clearing of forests for agriculture. For more than a decade, we and our colleagues have been studying pukeko, with the bulk of our research carried out in Shakespear Regional Park, about fifteen miles north of Auckland. Our study area is a combination farm and wildlife refuge. With hunting prohibited and lots of good nesting habitat, the pukeko population in the park is relatively dense compared with those on private land.

At Shakespear, territorial groups usually include three to five breeding males, two breeding females, and several nonbreeders of both sexes—the young of previous broods. In the early spring, males build several trial nests; breeding females eventually choose one in which to lay their eggs. Nests are situated in clumps of rushes or tall grass and are usually surrounded by water. Birds that don't win good territories are forced to breed away from water and in less dense vegetation. As a result they suffer more attacks on nests by the local marsh hawk—the Australasian harrier. Nests are shallow depressions when first constructed, but the males add more material throughout incubation, and if the nest is threatened by rising waters from heavy rain, material is quickly added to raise the level of the nest bowl.

Individual females lay from three to six eggs and sometimes produce another clutch when the chicks are half-grown. Each female's eggs have their own distinct pattern of dark-brown spots and blotches on a buff background and can easily be told from another's. All the male and female breeders incubate the eggs, which takes about twenty-three days. Although able to walk and swim within one day of hatching, chicks still need to be fed and brooded, and every member of the group helps out in these tasks. (First-clutch chicks even help feed second broods.)

To identify individual pukeko for study, we catch them in walk-in funnel traps baited with barley and corn. Adult pukeko are marked individually with colored leg bands and wing tags and then released. Because they spend most of their time in the open and rarely fly, we can observe them almost continuously. Furthermore, they rapidly learn to associate colored flags with a small quantity of provided grain. Thus, we are able to draw them to specific locations to observe how they defend territories and compete for food.

We soon learned that pukeko feeding etiquette is extremely ritualized. Males dominate females, and older birds dominate the younger, resulting in a linear hierarchy that remains constant from year to year. The top, or "alpha," male dominates all others in the group and regularly displaces subordinates with its beak and feet in disputes over food. Social status, we



learned, also holds sway across a range of other activities, such as changing of incubation shifts, territorial defense, and even preening (a service solicited by dominant birds from subordinates).

To acknowledge rank, pukeko adopt various postures in accord with their status. (Aggression, for instance, is signaled by holding the head high; submission involves a sort of "bow," in which the head is held close to the ground.) Such posturing assures that out-and-out fighting within the group is rare.

According to Darwinian theory, competition between individuals for the opportunity to reproduce should be particularly intense because natural selection favors those who can best perpetuate themselves genetically in future generations. Males and females compete differently, however. Because males are constantly producing millions of spermatozoa, a male's breeding possibilities are limited only by the number of times he can get to a female in time to fertilize an egg. Therefore, competition for females is usually the rule among males. On the other hand, a female's reproductive success is sharply limited by the number of eggs she can lay. So females are more likely to compete over resources—such as food or nests—that are essential for producing eggs and for bringing young to maturity.

Like birds that breed in pairs, most communally breeding birds follow the typical pattern. Male acorn woodpeckers and dunnocks closely guard females to prevent other males from copulating with them, especially just before and during egg laying. Female anis and acorn woodpeckers are often fiercely competitive, destroying or tossing out of the nest eggs belonging to other females.

We expected that among pukeko, too, dominant males would attempt to monopolize females and that dominant females would attempt to insure that the greatest number of eggs in a communal clutch are theirs. But the behavior of mating pukeko surprised us in several ways.

The alpha female somehow manages to lay at least one more egg per nest than the beta and to produce more clutches within a breeding season. Yet breeding females did not compete for the use of the shared nest. And we found no evidence that eggs were being destroyed or tossed out of the nest;



all eggs laid were still present when hatching began.

We did, however, see one type of interaction between the alpha and beta females that could be interpreted as an assertion of reproductive dominance by the alpha. An alpha female occasionally mounted a beta when the latter was alone or when both were being courted by one or more males. About a quarter of these attempts resulted in a "complete" copulation act. (Copulation in birds is achieved by the male pressing his genital opening, the cloaca, against the female's cloaca and releasing sperm. In female–female cases, the two birds make cloacal contact.) All such "matings" occurred just prior to or during the egg-laying period and may have had something to do with the beta's laying fewer eggs.

If we thought that the lack of overt competition among females was unusual, our observations of males competing for receptive females surprised us even more. Pairs may copulate as much as two months before the start of the egg-laying period, but sexual activity is most intense in early spring, beginning a week before egg laying. At this time, males hound females relentlessly—following and enticing them into a receptive posture by raking their large feet across the females' backs.

A male initiates courtship by walking behind a female in a characteristic upright gait and emitting a loud humming call. Several other males may join in at this point, forming a line behind the first male. If the female is receptive, she assumes a hunched posture, and the male steps onto her back and slowly positions himself to make cloacal contact.

Among the males themselves, however, things are relatively peaceful. We saw no outright hostility and, remarkably, found no relationship between a male's status and the number of times he copulated with a female. Still, we could see that social status played a subtle role in mating attempts. Most commonly, males simply look on while other males court a breeding female. But the odds are ten to one that a male that *does* interrupt a courtship will be the alpha male. And the mode of interception is extremely interesting. The alpha male runs in front of the courting male and crouches in a hunched posture. At this, the males stop following the female, and the male closest to the crouched alpha male mounts him. Occasionally, the subordinate male makes cloacal contact with the "decoy female" and ejaculates. In seducing his rivals, the alpha appears to be taking advantage of the hunched posture—a stimulus to copulation that apparently is so strong that males can't resist it, regardless of the sex of the signaler.

When it comes to interrupting a copulation, the alpha male's behavior is again not what we expected, as he interferes with the female, not with the male standing precariously on top of her. The interrupter typi-

Breeding females in a communal group usually share a single nest, to which the dominant female usually contributes one more egg than does her cobreeder. In this case, males have built two contiguous nests, left, in which three females have laid eggs. Below: A communal group feeds on grass and grubs in a pasture.

Both photographs by John L. Craig



cally pecks at the copulating female's head and neck area. This invariably causes her to come out of the hunched posture, toppling the mounted rival.

Yet such interference was relatively uncommon. More often, alpha males made no attempt to interrupt a mating of a rival male but instead stood aside and watched the copulating pair. The voyeur often courted the female of such a pair after the other male had dismounted, but she rarely responded to his gestures.

We did wonder, however, whether alpha males were being selective and only interrupting subordinates at the critical moment when eggs could be fertilized. We designed new experiments, only to find that when the female was most likely to be ovulating, alpha males did not monopolize matings or actively prevent others from copulating. As many as three males might copulate with the same female during the three hours when she is most fertile.

Overall, individual alpha males were more likely to allow a mating to occur than they were to interrupt it. Furthermore, there was no indication that alpha males interrupted or ignored some males more than others or that females were only receptive to certain males within the breeding group. Matings in general seemed to operate on a first-come, first-served basis, regardless of social status.

Given all the couplings that were going on, we reasoned that all group males had a good chance of fathering one or more offspring per clutch. Dave Lambert and his group at Auckland University have subsequently carried out DNA fingerprint analysis, a molecular genetic technique using blood samples that assigns paternity and maternity to each offspring with a high degree of accuracy. They found that almost all pukeko broods are fathered by more than one male, with alpha males fathering more offspring, on average, than subordinates do.

Why, then, are pukeko so diplomatic in their mating behavior, and why are they so accepting of their relatives as mates, when few other animals are? We believe it has to do with why pukeko live in groups in the first place.

Most juvenile birds eventually disperse from their parents' territories to find a mate and breed. This pattern assumes plenty of empty breeding habitat, which is the situation of the pukeko living on New Zealand's South Island. Because that island's climate is harsh, pukeko adult mortality is high, and juveniles regularly leave their natal territory to breed as yearlings.

In Shakespear Park, however, new nesting habitat is extremely limited. With few natural predators and a relatively benign climate, breeders are long-lived, making breeding vacancies in good habitat rare. Thus, any pukeko parent that pushes an offspring out of its territory might be putting its own reproductive fate into a cul-de-sac. (In Darwinian terms, it's not

Nic Bishop

A courtship line of three adult males follows a breeding female, below. In the background, a nonbreeding helper or another adult female is preening. Right: Pukeko are unusually tolerant of sexual rivals. Here, a second-ranked male copulates with a female as the alpha male looks on.

Don Hadden



just the surviving offspring that count but whether those offspring leave descendants to carry on their genes.)

So letting offspring remain in the safety of the natal territory would be an advantage to a parent when habitat is scarce (and assuming that food is not in short supply). In return, the breeders would have a reserve of territorial defenders on hand. This is important since stringent defense of nesting habitat appears to be vital for breeding pukeko. These extra birds can also help feed dependent chicks.

Even though offspring become potential breeding competitors as they grow older, losing out to one's offspring on reproductive opportunities may be a lesser evil since offspring share about half of each parent's genetic material. Becoming the sexual partner of a relative or allowing a relative to breed in your place would seem to trade off gaining descendants against the possibility of genetic defects. Close inbreeding potentially increases the chance of inheriting lethal recessive genes that would normally be unexpressed. Yet in a population where inbreeding is strong, selection pressure usually weeds out these harmful genes in a few generations. Thereafter, deaths caused by genetic factors may be rare or no more common than death from other causes. For pukeko, the high costs associated with dispersal may actually promote inbreeding—or at least lessen the need to avoid it.

In fact, seven years of data have shown that between 70 percent and 90 percent of pukeko at Shakespear Park remain in their natal territory, and 67 percent breed incestuously (father with daughter, mother with son, or brother with sister). The last has been confirmed by genetic analysis. The rare bird that leaves a natal territory is usually an adult male that moves to neighboring turf. This suggests that the relatedness of the entire population is also very high. Of the 223 birds we have banded, only one has ever been sighted outside the one and a half square mile park.

To be sure, the total number of young that can be raised in a group is limited, and hence the per capita reproductive success is always greater for birds that breed in pairs rather than a group. However, as in human society during an economic recession, pukeko parents may have little choice but to allow their children to stay at home. In so doing, the offspring inevitably seem to join in the family business of reproduction. □



Fire on the Moon

by Gail S. Cleere

One summer evening in 1178, five monks in Canterbury, England, sat watching the night sky darken:

> There was a bright new Moon, and as usual in that phase, its horns were tilted towards the East.... Suddenly, the upper horn [of the Moon] split in two. From the midpoint of the division, a flaming torch sprang up, spewing out fire, hot coals, and sparks. Meanwhile, the body of the Moon which was below, writhed, as it were, in anxiety.... Afterward it resumed its proper state. This phenomenon was repeated a dozen times or more.... Then, after these transformations the Moon from horn to horn, that is along its whole length, took on a blackish appearance.

This description of what they saw was recorded by Gervase of Canterbury, a reputable source. What had these monks witnessed? "According to the Church and the Aristotelian philosophy current at the time, the moon and other heavenly bodies were perfect and immutable, as opposed to the corruptible, changeable earth below. Such a phenomenon would have seemed impossible, and contrary to all belief and faith," observes LeRoy Doggett, an archeoastronomer at the U.S. Naval Observatory in Washington, D.C. Whatever they saw, the five, who excitedly told their tale to Father Gervase, swore they were "prepared to stake their honor on an oath that they had made no addition or falsification to this report."

According to Jack Hartung, a geologist at the State University of New York at Stony Brook, the event reported in 1178 seems to be unique; no similar event of that magnitude or description has ever been reported. He says the phenomenon observed by the monks might have been caused by cloud layers in the earth's atmosphere or by turbulence just above the western horizon or even by a meteor falling along their line of sight to the moon, but it is more likely that something very large hit the lunar surface.

An asteroid or a piece of a comet may have slammed into the moon that summer evening, possibly creating on the back of the moon the giant crater Giordano Bruno (named after the sixteenth-century scholar who was burned at the stake for, among other things, suggesting life on other worlds). The phenomenon described in the chronicles is reasonably consistent with what scientists might expect to see if a large impact occurred. The crater Giordano Bruno is located in roughly the right position to have produced the "flames" so vividly described by the five witnesses. Furthermore, the Giordano Bruno crater is relatively young, judging from the bright, fresh appearance of the rays of ejecta from the crater.

The monks did not know that the large impact they witnessed probably set the moon ringing like a bell. Astronomers Derral Mulholland and Odile Calame point out that the moon, like any other physical body, will suffer "free oscillations" when subjected to violent impact—similar to the vibrations of a tuning fork that has been struck. On the earth, after a very large earthquake, such vibrations can be detected for several weeks. Some oscillations will fade away relatively quickly, but the free oscillations in the rotational motion of the moon have very long damping times, detectable even now, 815 years after the monks witnessed the event. Indeed, the current amplitudes of these oscillations are consistent with a large impact occurring some eight centuries ago.

These lunar oscillations can be detected by the Lunar Laser Ranging Program carried out by the University of Texas's McDonald Observatory and by observatories in France and Germany. Pulses of laser light shot from the observatories strike reflectors placed on the moon's surface by three Apollo missions. Reflected back to the earth, the light is picked up by telescopes about two and a half seconds later. Its return time can be measured to within ten-billionths of a second and its distance to within about an inch. Mulholland points out that while lunar laser ranging may seem spectacular and does require some technical wizardry, "there is nothing to see that rivals *Star Wars*. There are only a few pieces of aluminum and silica sitting on our nearest celestial neighbor. Here on Earth, a few people try to find them with complicated flashlights."

Despite Mulholland's modesty about the program, it has contributed to some impressive scientific advances in lunar dynamics, geophysics, and relativity. According to Peter Shelus, director of the laser ranging operations at the McDonald Observatory, among the greatest contributions being made by the Lunar Laser Ranging Program is the extremely precise measurement of the earth's orientation in space. Along with radio astronomy and artificial satellite laser ranging, the McDonald program can determine whether the earth is speeding up or slowing down in its rotation on its axis and whether or not we must add or delete some time (leap seconds) in the day to keep our clocks accurate from year to year.

The laser beams bounced off the moon have improved nearly every aspect of our knowledge about the moon's dynamics, and they have detected lingering vibrations consistent with an ancient impact, vindicating the Canterbury monks—although it's taken some eight centuries.

The Planets in July

Mercury starts out the month as an evening object, low in the western sky just after sunset, near the stars Castor and Pollux in Gemini. By midmonth, Mercury reaches inferior conjunction, passing between the earth and the sun. By the end of the month, Mercury emerges as a morning object, sharing the predawn eastern skies with bright Venus.

Venus is a brilliant morning planet this month, rising a few hours after midnight and residing in the constellation Taurus.

n the 15th, Venus is 13° above the red r Aldebaran in the Hyades star cluster. atch as the waning crescent moon passes ove the planet during the next twenty- ur hours.

Mars is in Leo and can be seen low in e west–southwest for some two hours ter sunset, with bright Jupiter trailing st behind it in Virgo. On the 22d, Mars is north of the three-day-old moon.

Jupiter is in western Virgo, high in the uthwest at sundown. Visually, Jupiter is ot far from the 3d-magnitude star Por- ma, named for an ancient goddess of ophecy. On the 24th, watch as the wax- g moon sails by just below the planet.

Saturn rises a couple of hours after nset among the faint stars of Aquarius. t +0.6 magnitude, Saturn is still consid- ably brighter than any of the surround- g stars. On the 7th, the waning moon ap- ears just above the ringed planet.

Uranus and **Neptune** cling to each ther in eastern Sagittarius, rising about hen the sun sets and setting as the sun ses. They reach opposition (opposite the un in our sky) within eleven hours of ach other on the 12th. Both are just above he roughly 3d-magnitude star Ascella. With a detailed sky chart and a good pair f binoculars, scan the sky just east of the agittarius "teapot," and you might be ble to spot them.

Pluto is in Libra but can only be ob- erved with the largest telescopes. It rises n midafternoon and is high in the south- rn sky at sundown.

The **Moon** is full on the 3d at 7:45 P.M., EDT; reaches last quarter on the 11th at :49 P.M., EDT; is new on the 19th at 7:24 .M., EDT; and reaches first quarter at 1:25 P.M., EDT on the 25th.

Gail S. Cleere writes on popular astron- omy and is a founding member of the nternational Dark Sky Association, an organization dedicated to preserving the kies for astronomy.





CELESTIAL FENDER-BENDER: THE PEEKSKILL METEORITE

On the night of October 9, 1992, a 27-pound meteorite crashed through a parked car in Peekskill, New York, making a small crater in the ground. Many people in the eastern United States saw the brilliant fireball as it crossed the night sky, and several documented its course on videotape. With the aid of these video-recordings, scientists hope to calculate the meteorite's orbit and trace the object to a known asteroid. Starting Friday, July 30, the car and the meteorite will be on display in the Museum's 77th Street foyer.

MOVIE DINOSAURS

In conjunction with the exhibition "The Dinosaurs of Jurassic Park," a motion-picture retrospective featuring prehistoric animals will be presented on Tuesday, July 20. Host Donald F. Glut, author of *The Complete Dinosaur Dictionary,* will show clips from numerous films, including *Gertie the Dinosaur, The Dinosaur and the Missing Link, Gorgo, Godzilla vs. the Smog Monster,* and *Baby, Secret of the Lost Legend.* The program takes place at 7:00 P.M. in the Kaufmann Theater. Tickets are $12 ($9 for members). Call (212) 769-5606 for more information.

PLANETARIUM SHOW FOR TREKKIES

The Hayden Planetarium's new Sky Show, "Orion Rendezvous...A Star Trek® Voyage of Discovery," will feature the voice of actor LaVar Burton, in his television role as Lt. Cmdr. Geordi La Forge, narrating a 24th-century voyage aboard the *Antares.* The starship will visit unexplored areas of the universe, including a sun 100 million times bigger than our own and the galactic graveyard of a star that died in a powerful explosion. Beginning Thursday, July 1, showtimes are Monday through Friday at 1:30 and 3:30 P.M., and every hour from 1:00 to 4:00 P.M on Saturdays and Sundays. For more information about Planetarium events, call (212) 769-5100.

SIGN LANGUAGE TOUR

On Saturday, July 31, at 1:45 P.M., a signed tour of the Hall of Ocean Life will be led by volunteers Robert Campanile and Gabriel Grayson. The tour is free with Museum admission. For further information, call (212) 769-5566.

These events take place at the American Museum of Natural History, located on Central Park West at 79th Street in New York City. The Kaufmann Theater is located in the Charles A. Dana Education Wing. The Museum has a pay-what-you-wish admission policy. For more information about Museum activities, call (212) 769-5100.



J. Beckett © AMNH 1992

The meteorite at left was once part of an asteroid that formed at the same time as the earth, 4.5 billion years ago. A collision with another asteroid produced a large fragment that came hurtling toward the earth at about 30,000 miles per hour. Slowed down by Earth's atmosphere, the fragment broke up, and this 27-pound, football-sized stone crashed into Michelle Knapp's 1981 Chevrolet Malibu, right, in Peekskill, New York.

Martin Prinz



Phelps Cabin, Arizona

by Robert H. Mohlenbrock

The high mountains of east-central Arizona are a world apart from the Sonoran Desert to the southwest and the arid mesas and plateaus of Navajo country to the north. These are the White Mountains, where winter temperatures often drop to 30° F below zero, snowfall averages six feet a year, and clear mountain streams ripple past towering spruces and Douglas firs. Dotted with small communities, such as Alpine, Eager, Springerville, and Greer, the region is divided between the Fort Apache Indian Reservation and the Apache-Sitgreaves National Forests. Among the biologically important locales on Forest Service land is a wetland and adjacent grassy meadow and forest that make up the 330-acre Phelps Cabin Research Natural Area.

The area takes its name from a log cabin on a former homestead, now unoccupied. The Research Natural Area is reached from the southern arm of the Mount Baldy hiking trail, which loops west of Forest Road 113. The trail climbs the slopes of the massive mountain but passes short of the summit, which is sacred ground owned by the Apache tribe. A few dozen feet from the trail head, the path bursts through a grove of blue spruces and quaking aspens into a meadow that flourishes during the growing season, from late April to September.

The meadow owes its presence to a combination of high elevation and southern exposure. Apart from some weedy bromegrass that grows along the hiking trail, it is pristine. The native grass species include Idaho fescue, Idaho bent grass, bluejoint grass, hair grass, and June grass. All are palatable to grazing animals, but domestic livestock are now excluded. The grasses generally produce inconspicuous flowers, but a number of wildflowers also bloom in the meadow. Among them are a blue flax, with a slender stem and a large flower; a magenta wild geranium; American harebell with its solitary, blue, bell-shaped, nodding flower; and three yellow wildflowers—a goldenrod, a groundsel, and a mountain dandelion.

The grassy meadow slopes toward the East Fork of the Little Colorado River, a sparkling stream only a few feet wide. Several wetland shrubs that are good indicators of unpolluted streams line the banks or grow in the flowing water. They are the western elderberry, thin-leaf alder, and three willows—coyote, Scouler's, and whiplash.

The marshy to boggy wetland that extends several feet back from either side of the creek, covering about thirty-five acres, is the focal point of the Research Natural Area. Botanists have recorded sixty-one species of flowering plants there, includ-



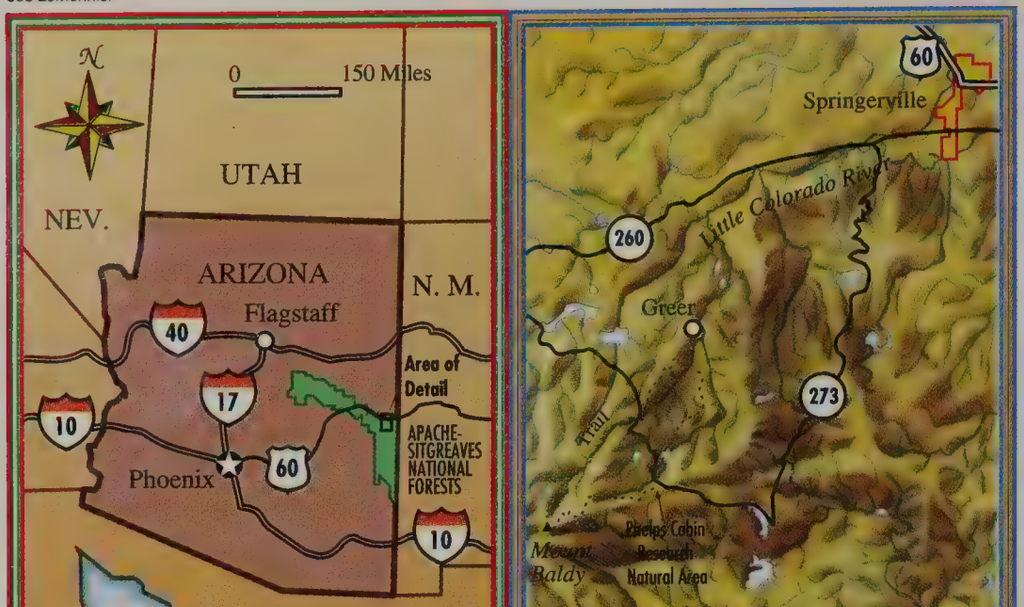
T. A. Wiewandt; DRK Photo



The sun rises on 11,403-foot Mount Baldy, in the White Mountains. Below, left: The marsh marigold grows in wetlands.
David Muench



Joe LeMonnier



Phelps Cabin

For visitor information write:
Forest Supervisor
Apache-Sitgreaves National Forests
Federal Building
P.O. Box 640
Springerville, Arizona 85938
(602) 333-4301

ing numerous grasses, sedges, and rushes and showier species representing a wide range of plant families. Among the common wildflowers are Rocky Mountain iris, marsh marigold, monkshood, two monkey flowers, a skullcap of the mint family, hemlock parsley, Fendler's cowbane, and a bog orchid. Corn lily, which stands up to five feet tall, has huge, round leaves that appear corrugated because of their elevated veins. Growing submerged in the water or with some floating leaves are the aquatic white-flowered buttercup, the little heart-leaved buttercup, and a waterwort. The yellow-flowered cinquefoil, a shrubby species nearly ubiquitous in North American wetlands, is scattered all across the wetland and advances upslope into the grassy meadows.

The Research Natural Area also includes 194 acres of the adjacent forest, made up of Engelmann spruce, blue spruce, and Douglas fir. Beneath these cone-bearing trees, which are more abundant as one climbs higher up the slopes o Mount Baldy, are rich layers of shrubs an wildflowers. The most common shrubs ar the gooseberry currant and bearberry hon eysuckle, whose twin blue-black berrie are nestled between a pair of lip-re leaves. The wildflowers include thre kinds of wild orchids, northern bedstraw and the false Solomon's-seal. Forests such as this are characteristic of more northerly regions. In all likelihood, the coniferou tree species and their associated flora wer driven southward by glaciation during th Ice Age. Then, as conditions warmed an the ice retreated, they were left isolated o the high, cool mountains.

Robert H. Mohlenbrock, professor emeri tus of plant biology at Southern Illinoi University, Carbondale, explores the bio logical and geological highlights of th 156 U.S. national forests.



Phelps Cabin overlooks the East Fork of the Little Colorado River and the adjacent natural meadow.
Dale Schicketanz

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slow moment at the fruit stalls in Florence, Italy
eve Meltzer

A Window into Science

by Paul Davies

Recently there appeared two biographies of the British mathematical physicist Stephen Hawking. Flushed with success, the coauthor of one of them approached me about the feasibility of writing another scientific biography. We soon came to the conclusion that Hawking was unique and that, with the possible exception of Einstein, no physicist was likely to excite wide public interest. The contrast with the artistic and literary community is stark: Biographies of the likes of Picasso or D. H. Lawrence abound and receive lavish attention and wide readership. I wonder why the difference is so great?

The answer stems, I believe, from the way science is taught at school. Personalities rarely enter to disturb the dry formulas and arcane procedures. Science is presented as a body of accepted fact, missing out on the anguish, the feuding, the doubt, the exhilaration, and the eccentricity. In short, science education tends to dehumanize the subject. An ugly side effect is that science is portrayed generally as a cold and sterile activity, thus perpetuating the damaging schism between what the novelist C. P. Snow, in a famous lecture of 1959, termed "the two cultures," a separation that presents the arts as humanizing and the sciences as dehumanizing.

Only very recently has the public become aware that this one-dimensional picture of science and scientists is a gross distortion. In large part this is due to the growth of so-called popular science writing. Increasingly, science books aimed at the legendary "intelligent layperson" are liberally spiced with entertaining anecdotes and racy stories about the men and women behind the bald face of science.

Mostly these books are written by journalists and tend to have an irritating, voyeuristic quality. Fortunately, there are exceptions. For some years, books and articles by Jeremy Bernstein have provided a wide public with a window on the world of science, melding sensitive and convincing biography with accurate scientific explanations. This happy mix is a product of the author's career—part practicing physicist, part journalist. Bernstein believes that "the very best popular science writing must come from scientists. For them, science is a part of everyday experience—their skin and bones."

Bernstein has a brilliant facility for weaving a good story around an important scientific theme. Over the years, his articles in the *New Yorker* have covered a range of exciting topics in physics, astronomy, mathematics, chemistry, and computer science. Each essay has a delightful Alistair Cooke quality about it—a sort of Letter from Wonderland. *Cranks, Quarks, and the Cosmos* reprints some of these pieces, together with other, less well known material, to provide a fascinating, random walk through the world of fundamental science.

Many of the essays focus on key figures in the history of science: Albert Einstein, Charles Darwin, Erwin Schrödinger, Niels Bohr, Alan Turing. But in place of a mere catalog of achievements, we learn of the complex relationships between scientists and their peers, the frequently convoluted nature of their paths to success, and the social and political context of their work. What comes through is not only a story of science as an intensely human—and humanizing—activity but also a sense of an enterprise that is secure in its foundation yet tantalizingly incomplete. We may justifiably feel confident that the scientific method is a path to reliable knowledge about the world, yet many pieces of t great cosmic jigsaw remain missing.

Not all of Bernstein's essays conce mainstream scientists, however. The a thor has a yen for the offbeat, too. W learn of Edwin Land, the obscure a reclusive inventor of the Polaroid came who devised some thought-provoking e periments in color vision, and the mus cian-mathematician Tom Lehrer, who

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CRANKS, QUARKS, AND THE COSMO WRITINGS ON SCIENCE, by Jeremy Ber stein. *Basic Books, $23.00; 220 pp.*

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erratic career left its mark with a famo song about the chemical elements. The same elements figure emblematically the tragic yet colorful life of the Jewi Italian chemist Primo Levi, survivor Auschwitz. Levi's own book *The Perio Table,* a collection of entrancing stori featuring particular chemicals, was minor best seller a few years before the a thor committed suicide in 1987.

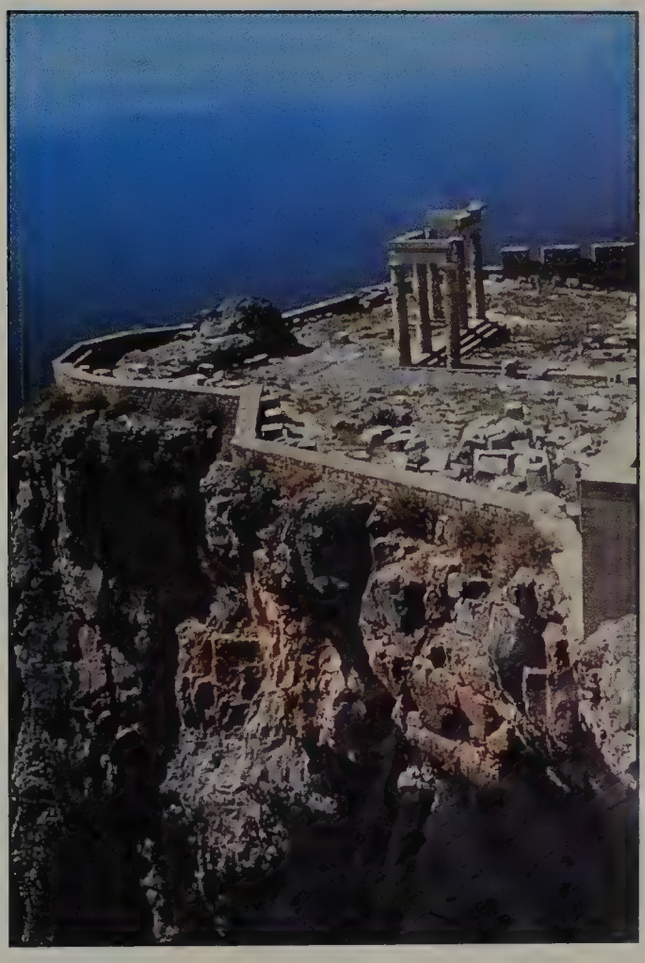
Perhaps the most valuable aspect these essays is the way in which they yie insights into the scientific process at wor something that is almost totally abse from formal science education. To t practicing scientist, scientific method is road to truth, yet to the public, science c seem like magic. Scientists are often su of their ground but cannot explain why a skeptical outsider. This can come acro as arrogance, and much of the bad pre that science receives derives from this cu tural gulf.

For example, I am often asked why find it comparatively easy to believe evaporating black holes and invisible co mic matter, but not in straightforwa



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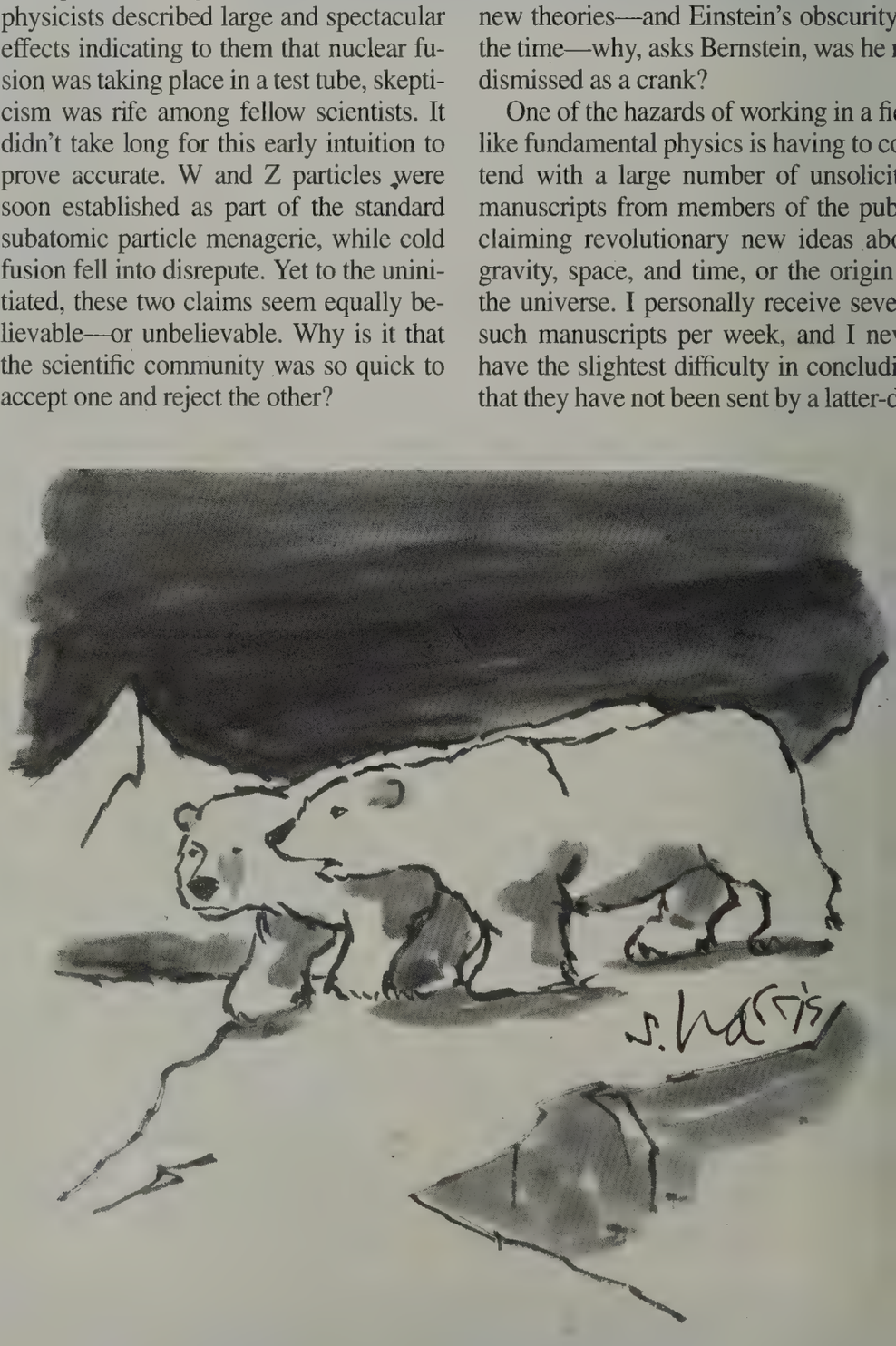
SATISFACTION GUARANTEED

things like ghosts and flying saucers that ordinary people apparently see all the time. The reason is not easy to explain to someone unfamiliar with the scientific process because the nature of scientific evidence and the relationship between theory and experiment can be very subtle.

Let me give an example. A few years ago, physicists at the European particle accelerator laboratory CERN (Conseil Européen pour la Recherche Nucléaire) announced the discovery of two new particles called W and Z. As far as I know, nobody questioned the reliability of the claim, even though of the thousands of particle collision events analyzed, only a tiny handful suggested the existence of new particles. By contrast, when two physicists described large and spectacular effects indicating to them that nuclear fusion was taking place in a test tube, skepticism was rife among fellow scientists. It didn't take long for this early intuition to prove accurate. W and Z particles were soon established as part of the standard subatomic particle menagerie, while cold fusion fell into disrepute. Yet to the uninitiated, these two claims seem equally believable—or unbelievable. Why is it that the scientific community was so quick to accept one and reject the other?

Bernstein addresses such questions his essay entitled "How Can We Be Su That Albert Einstein Was Not a Crank The young Einstein, it will be recalle was unknown to the physics communi He did not even have a proper scienti job but worked as a clerk in the Sw patent office. From this unlikely locati he helped create not one but two ma revolutions in physics in the space of a f months. His papers came totally out of blue and challenged the very basis of thodoxy. In spite of this, his ideas were gerly embraced, and within a few yea Einstein's special theory of relativity h replaced Newton's conceptual framewo as the accepted picture of space, time, a motion. Given the radical nature of new theories—and Einstein's obscurity the time—why, asks Bernstein, was he dismissed as a crank?

One of the hazards of working in a fi like fundamental physics is having to co tend with a large number of unsolicit manuscripts from members of the pub claiming revolutionary new ideas abo gravity, space, and time, or the origin the universe. I personally receive seve such manuscripts per week, and I nev have the slightest difficulty in concludi that they have not been sent by a latter-d



"It's not easy to have a symbiotic relationship when no one else is around."

Einstein. To be taken seriously, a new theory cannot address a topic in isolation. It must make contact with the existing body of knowledge. For instance, Einstein's special theory of relativity reduces to Newton's theory of mechanics when the speed of the system involved is much less than the speed of light.

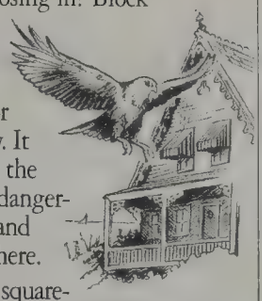
The twin attributes of correspondence with existing theory and predictiveness, Bernstein believes, distinguish proper science from its imitations. By contrast, crank papers make no attempt to recover existing theory and rarely predict anything remotely testable. Coming back to the discovery of the W and Z particles, these entities are key indicators in a theory that amalgamates the electromagnetic and weak nuclear forces. This so-called electro-weak theory was formulated by physicists Steven Weinberg and Abdus Salam in the late 1960s and satisfies the two Bernstein criteria beautifully. It encompasses the textbook theories of electromagnetism and the weak nuclear force at low energy, but at high energy it predicts a measurable departure from both these theories and the appearance of two new particles. When CERN eventually built an accelerator to achieve the necessary energies—and the W and Z particles seemed to have turned up on cue—physicists needed little convincing that the discovery was genuine.

Of course, not all science proceeds so flawlessly, and Bernstein describes messy episodes where the evidence is ambiguous or distorted, or where confusion reigns. There are also many blind alleys where seemingly good ideas just lead nowhere. But on the whole, science advances us in the direction of reliable knowledge, and it has become an indispensable part of our culture. The miracle to me is that we human beings can do science at all, that we can apply esoteric procedures to uncover the hidden order in nature. With scientific values under attack from many sides, it is essential for scientists such as Bernstein to provide the wider public with an accurate image of what practicing science really amounts to—a human adventure without parallel that permits us to glimpse nature's innermost secrets with reasonable confidence that we are not misleading ourselves.

Paul Davies is professor of mathematical physics at the University of Adelaide, Australia. He is the author of more than twenty books; his latest are The Matter Myth *and* The Mind of God.

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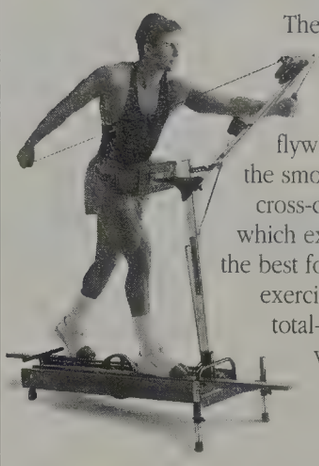
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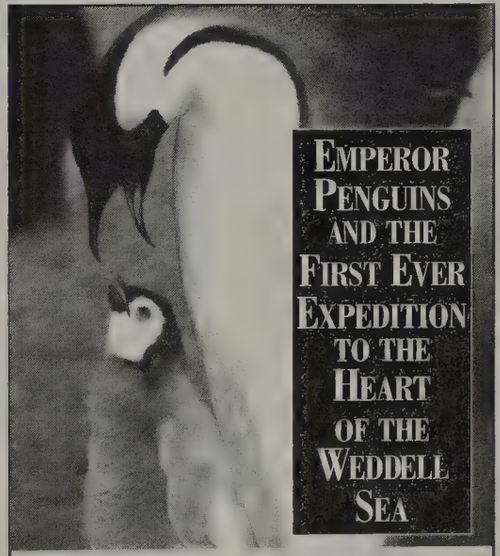
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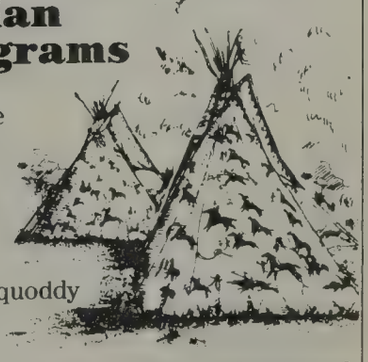
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The Good Seed

Its origins lost in prehistory, wheat now supplies the human race with one-fifth of its calories

by Raymond Sokolov

When the horticultural writer Lee Reich announced this spring that he was going to grow a patch of wheat in his garden in the Hudson Valley, it was a piece of real boldness. Normally, no one would have been particularly surprised or impressed if the author had revealed that he intended to make a pencil bloom. But even Reich realized that wheat was a special kind of undertaking, even for a big-time green thumb like himself. He wrote:

> I already have two excuses ready in case of poor yields. First, I am planting wheat in spring. But best wheat yields are obtained where wheat is grown as a winter crop. Winter wheat is sown in late summer, grows through autumn until put to sleep by winter cold, then begins growing again by early spring, ripening its seed heads by late spring.
>
> The other inherent limitation in my wheat harvest will be my choice of variety. I intend to go to the local health food store and buy a handful of whatever wheat berries are available. The problem is that there are many, many varieties of wheat—not surprising for a plant that was cultivated in the Nile Valley 9,000 years ago! In America alone, more than 200 varieties are grown.

Wheat's relative rarity in the Northeast is only, as Reich says in the same column in the *Huguenot Herald,* a result of the far better growing conditions that exist elsewhere, farther west. But this is only part of what makes Reich's wheat venture such a delicious self-dare. Even if he were living in Montana, he would be breaking fresh ground, as it were, for a gardener. Technically, wheat falls under the heading of horticulture as much as dahlias or lettuce. But in our day, growing *Triticum aestivum* is an industrial job. The world's wheat crop is immense, but almost none of it is grown in gardens by individuals for home consumption. And because of advanced forms of storage and transportation, it has been possible to concentrate wheat production (and the production of other fundamental grains) in those parts of the world that are best suited for it.

This means that the largest and most crucial part of world food production is now a transnational event run by giants. It also means that wheat is, in principle, available anywhere, at any time, instead of being a crop of limited range that gives way, in more challenging climates, to other staples. In the Old World, wheat was once rivaled by oats, barley, rye, and buckwheat. Today, these grains occupy special niches in the human diet. Some people barely consume them at all. And almost no one supplements industrially grown wheat with backyard garden wheat in the way that possibly millions of home gardeners supplement agribusiness's tomatoes with their own vine-ripened crop.

Perhaps Reich's wheat will justify the effort. Perhaps his flour will taste better than anything he can buy, even from a custom miller, or better than flour he might mill himself with one of the milling machines available to hobbyists and other doubting Thomases of the health food fringe. Certainly, assuming that his crop does prosper, Reich will be the only person I know for whom words like reap, thresh, winnow, flail, and chaff have a direct meaning.

This is a very odd state of affairs, considering how our lives are built on the hybrid grasses of the *Triticum* genus. The origins of wheat, and almost everything important to know about this useful plant, are buried in prehistory or hidden away in today's mammoth fields and behemoth mills. The same could be said of all the other staple grains, but wheat is the pr eminent case. Today, wheat ranks first production totals among the world grains, and it accounts for more than 2 percent of the total calorie consumption the human race.

We know what we know about the or gins of modern wheat (and of other mo ern food grains) in two ways: from genet research and from that subsection archeology called paleoethnobotany.

Archeological fieldwork in this disc pline is not outwardly glamorous. Like a archeology, it is a learned version of ditch digging conducted in slow motion and miniature, sometimes laborious and su baked, other times a dank, bone-chillin business pursued in caves colonized b chittering bats and hip deep with the guano.

Human excrement is a central feature paleoethnobotany because accidentall preserved feces, called coprolites, ofte contain traces of undigested food, particu larly seeds. As Daniel Zohary and Mar Hopf explain in *Domestication of Plan in the Old World* (Oxford, 1988): "whe faeces are charred, desiccated, or wate logged, they often contain numerous iden tifiable plant fragments, which indicate th content of the human food in the teste culture." Zohary and Hopf cite the extra ordinary example of several corpse pulled from Iron Age sites in Danish pe bogs. The corpses were so well preserve that it was possible to do a "detailed analy sis of the last meals still contained in th stomachs."

Other sources of archeological dat about plants include charred or carbonize plant remains (sometimes including whol ears or entire caches of grain that wer burned and then left undisturbed for thou



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sands of years) and imprints left on pottery, bricks, and plaster. From such humble relics, investigators have reconstructed a complex vision of agriculture in neolithic times, when human societies all over the world were switching from hunting and foraging to farming.

Richard S. MacNeish surveys the current state of research in *The Origins of Agriculture and Settled Life* (University of Oklahoma, 1991). He begins by sketching the history of theories on the origin of agriculture. The outsider may be surprised at how much first-rate theorizing has been done about such an apparently straightforward development as agriculture. But the stakes are high: agriculture seems to go hand in hand with a settled life, in villages and then cities; and a settled life is the main prerequisite for civilization. It matters greatly, then, exactly how the human race evolved from nomadic bands of illiterates into rooted agricultural settlers with the time and the societal need to keep records. Unfortunately, the physical evidence for this great shift—perhaps the most fundamental advance in human history—is thin and can be interpreted in many ways. Thus the temptation to theorize.

As it happens, the first two important theorists were both Marxists but held completely opposite views about how economic forces had prompted the shift from food collection to food production in p historic times. Both men refined th thinking and published it in its most co plete form, quite separately, in 1951.

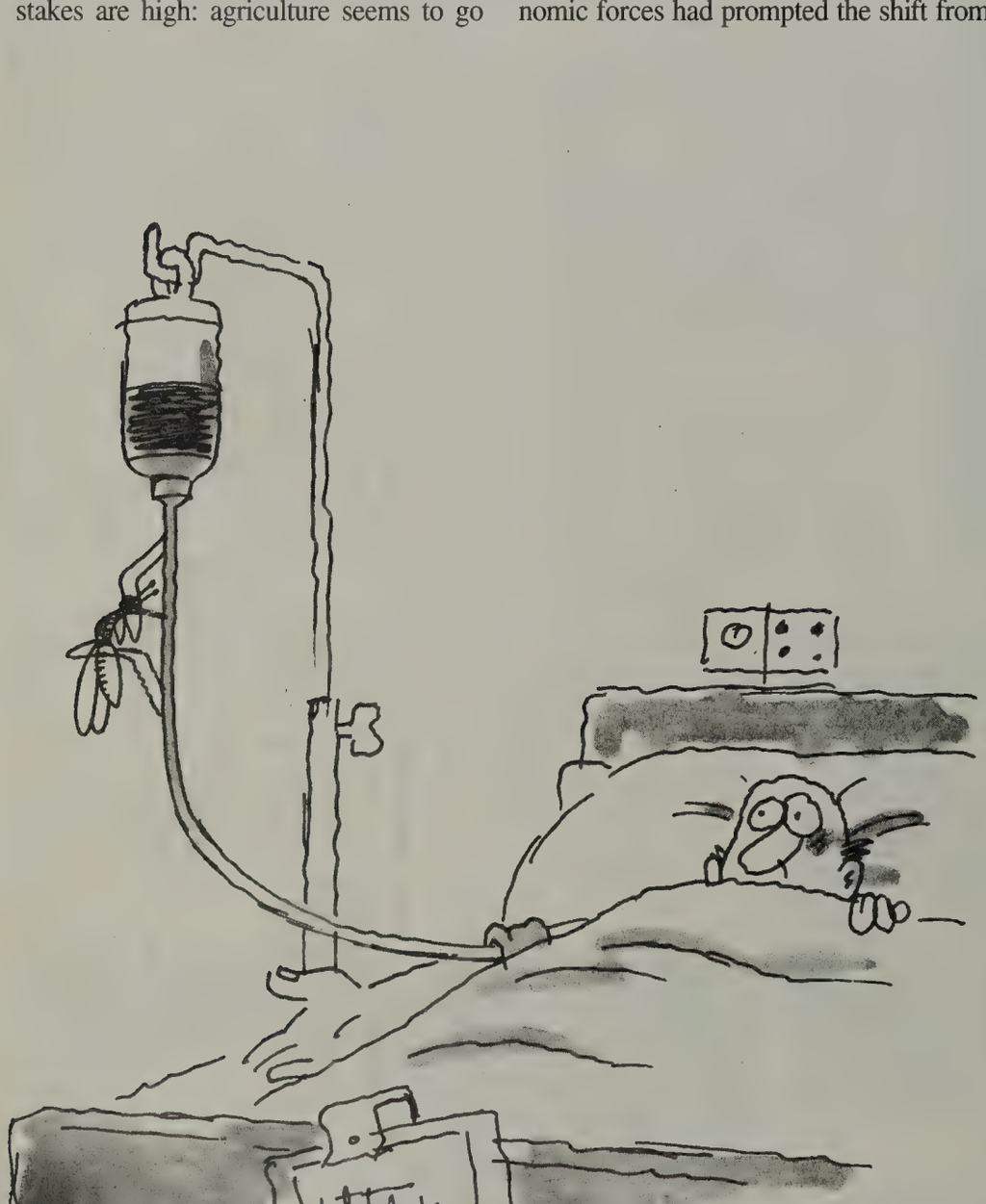
The British archeologist V. Gord Childe believed that (in MacNeish's su mary)

> the fundamental event in the establishm of agriculture...is the ending of the Ple tocene with its concomitant changing c mate.... In the Near East, desiccation e panded the deserts, causing a concentrati of plants, humans, and animals around a ries of oases. Recognizing the food pote tial of the associated plants and animals, h mans began to experiment with them. Th experimentation led to a new means of fo production—agriculture (i.e., the planti of seeds). Associated with this shift was t Neolithic Revolution, characterized sedentary village life, expanding popu tion, the use of ground-stone tools, the d velopment of ceramics, and the emergen of a new type of social (and political?) org nization.

On the other side of the fence was t distinguished Soviet botanist Ivan Vavil who sent out teams of colleagues all ov the world to gather plant evidence to pro that increased population and new tec nology were the causes of settled agricu tural life rather than the results of an env ronmental crisis. His greatest contributi was not, however, at this high theoretic level, but closer to the ground. His tea gathered an enormous amount of data, a Vavilov fitted that data into a framework great influence. He concluded that, MacNeish's words, "areas with the grea est concentration of domesticated pla varieties were the 'hearths' of domestic tion; that is, the centers in which domes cation was first practiced and from whi all later use of domesticated plants a agriculture radiated and diffused."

Vavilov's eight hearths were Chin India, the Near East, highland Guatema the Andes, the Sudanic Abyssinian are the South American tropics, and Southea Asia. Vavilov and his followers believ that humans gravitated to these areas b cause of the abundance of edible plan growing there. The populations of wel fed, oasis-foraging peoples grew, and plants had to be domesticated to meet i creased demand reliably.

Vavilov's life ended in tragedy, owing his loyalty to mainstream botany a Mendelian genetics. Official Stalinist bio ogy, under the leadership of Trofim L senko, rejected Mendelianism in favor the principle of the heritability of acquire characteristics. Vavilov was sent to t



lag, where he died in disgrace and be-
ne the leading martyr to Stalin's repres-
n of scientific thought.

In the world at large, his ideas have
en superseded, or at least significantly
dified, in the light of later research in
heology and plant genetics. MacNeish,
his own trilinear theory, reduces the
mber of hearths—he calls them Cen-
s—to four (Near East, Far East, Meso-
nerican, and Andes). And he believes
t he can account for the rise of plant do-
stication and settled life in any given
ce with one of his three complex, mul-
tage hypotheses. They all share three
cessary conditions: potentially domesti-
ble plants, a plantable environment, and the reduction of food resources because of the extinction of huntable animals in the post-Pleistocene.

MacNeish himself is careful to stress that his finely wrought structures are based on highly fragmentary evidence. But for those of us who stay at home and eat bread in late-twentieth-century cities, his hard-headed scenarios, tying together the domestication of wild grasses and the beginnings of urban life, are the raw material for vivid daydreams about our roots and the dawn of our culture.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.

Harold Pinter's play "The Birthday Party" introduced me to the idea of fried bread. And it was not a pretty introduction. As the play opens, an elderly couple are discussing breakfast in an aggressively dull and infuriating manner. She asks him if he liked his fried bread.

"Was it nice?"

"Yes, very nice."

And so on and so on.

Never having eaten fried bread, I assumed it was the epitome of bad British food, a corruption of taste consisting of limp white bread dripping rancid bacon fat.

Then, one morning years later, I found myself with a pan of hot bacon grease. (It was so long ago that I routinely fried bacon to go with fried eggs at Saturday breakfast.) And, remembering the Pinter play, I thought, why not try it? Very nice white peasant bread was at hand. I sliced it and dropped a slice in the very hot bacon grease. It was golden brown in a second. Drained on paper towel, it was a most delicious thing. I made a few more.

These days, I rarely try this adventure in high-fat, high-cholesterol dining, but once in a while it can't hurt. If you substitute goose fat for bacon fat, some nutritional experts will tell you that you have sidestepped the cardiovascular threat. With olive oil or one of the other non-artery-closing oils, you are safer, except for the calorie boost. Good cooking practice—very hot oil—will keep the grease level as low as possible.

Healthful (?) Fried Bread

Sliced bread
Oil or bacon drippings or goosefat or butter

1. For best results, the first time you do this, fry one piece of bread at a time. Use a cast-iron skillet slightly larger than the bread slice. Fill it with least a quarter-inch of oil or melted fat. This may look repulsive as you begin, but you don't want to be constantly replenishing the oil or fat especially because reliably hot temperature is the key to crisp success. Leftover oil or fat can be reused.
2. Heat oil or fat just until it begins to smoke. I could list the smoke points of all the various oils and fats you might decide to use for this recipe, but this would inject a preposterous note of scientific precision into what is, after all, the most primitive sort of cooking, meant to use up old bread and the residue of bacon frying. The really important thing is to wait until the oil or fat is very hot, so that it will immediately seize the bread (or "surprise" it, as the French say) on contact and will not make it soggy. As soon as a vapor or "smoke" rises from the pan, carefully immerse a slice of bread in the oil or fat. Using tongs is the best way to avoid splashing 370-degree fat on yourself.
3. The bread should sizzle loudly and brown almost immediately. Turn with the tongs. Cook for a few seconds more and remove to paper towel. If the bread burns right away, then the fat is too hot. Lower heat, wait a couple of minutes, and try again. It should not take much trial and error, if any, to get this process going. Continue until you have as many slices of fried bread as you need. As the level of the oil or fat reduces, take special care that the temperature does not rise too high.

Variations: If you fry two or three garlic cloves in the oil (and remove them when browned) before you start frying the bread, the oil will impart a garlic flavor to the bread. This process is essentially the same as making croutons. Instead of using slices of bread, cut the bread in triangles or dice it, then fry. Add to soups.

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Although common loon chicks can swim and perform rudimentary dives in their first days, a parent's ample back makes a tempting raft for a tired or chilly young bird. Such a cushion offers respite from cold lake waters and protection from northern pike and muskellunge, which are apt to snatch a baby loon from the water's surface and devour it. A willing parent will submerge slightly to allow chicks to embark and may partly lift a wing to keep them from sliding off. At other times, a chick may gain access by grasping the adult's feathers with its beak.

Common loons are one of several kinds of water birds that provide ferry service to chicks. This pair nested on an island in Oba Lake in Ontario's Algoma Wilderness. The chicks, less than a week old, were asleep on one parent's back when the other appeared with a minnow. One chick woke and scrambled aft. Eyeing the situation, its sibling soon got in on the action. Over the course of a half hour, the chicks downed more than twenty catered minnows.—*J. R.*

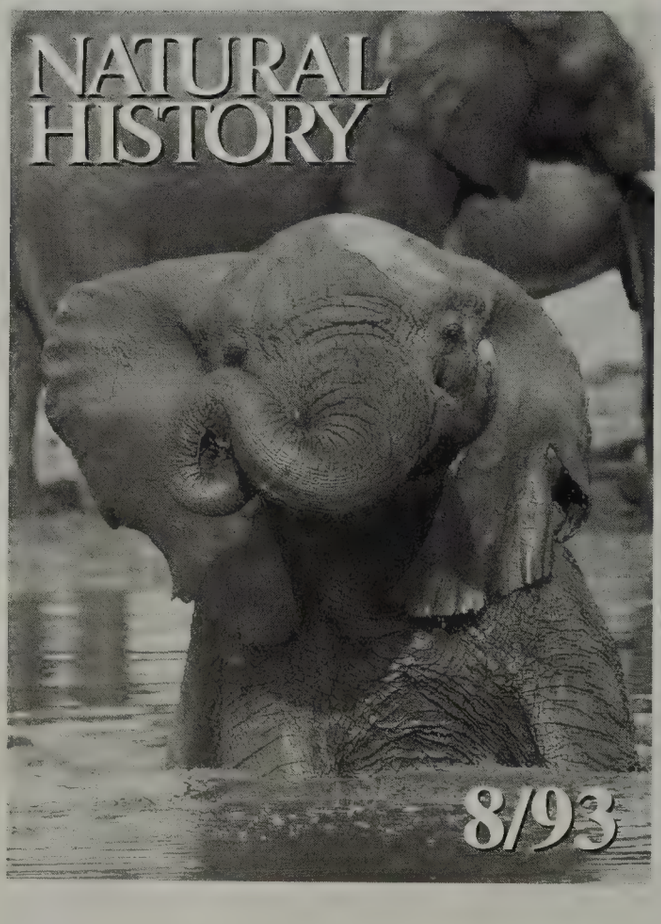
Photograph by Rich Clark





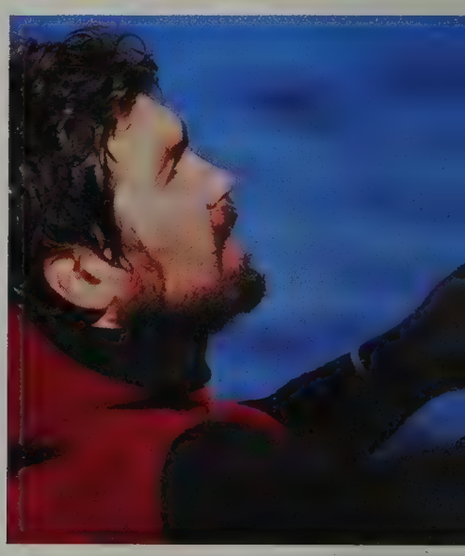
Hot Times in August

When the dog days of summer descend on us, we flee to the beaches, go into slow motion, or hide in air-conditioned cubicles. But a few creatures thrive in the heat. They are the subjects of next month's NATURAL HISTORY, a special theme issue that will help you keep your sense of natural wonder during the hottest month of the year. It will include articles and pictures about:



- A deadly viper that burrows into the hot sands of the Namib Desert—hidden completely, except for its alert eyes
- Camels that sit with their noses pointed to the sun, absorb heat in their humps, urinate on their legs, and have changed the shape of their blood cells to overcome the desert heat
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- Other influences of heat on the evolution of the upright, naked ape
- Prehistoric Indians in the Southwest who kept cool naturally
- The dangerous problems that penguins face when the temperature rises
- A plant that grows on stilts to get above the hot Australian sands
- An ant in the scorching Namib Desert that scoots up a stem of grass to cool off when its temperature climbs to lethal limits
- And much more, including the pleasures of ice cream and the improprieties of skinny-dipping

Authors



Richard A. Wahle (page 42) continu to be interested in the impact of ecologi processes on the early life stages of a mals. After receiving his Ph.D. from University of Maine, he became a po doctoral associate at Brown Univers where he studied the settlement behav of barnacle larvae. To him, barnacles an experimentalist's dream because th settle in the intertidal zone and stay p Armed with some new ideas from that perience and with support from the N tional Science Foundation, he continu his lobster work in Maine and Rhode land, where he is now investigating h ocean circulation and habitat quality aff settlement patterns and the fate of lobst in their first few years of life. One lo term goal is to see if such information useful in forecasting trends in the lobs fishery. Wahle is now a research associa and also teaches, at the University Rhode Island. For more on the ecologi and evolutionary significance of bo size, the author suggests *Scaling: Why Animal Size So Important?* by Kr Schmidt-Nielsen (New York: Cambrid University Press, 1984) and R. H. Peter *Ecological Implications of Body Si* (New York: Cambridge University Pre 1986). Wahle also recommends *Lobst ing and the Maine Coast,* by Kenneth Martin and Nathan R. Lipfert (Ba Maine Maritime Museum, 1985), "a wo derfully written history of the fishery w some good old photographs."

Although **Graham N. Stone**'s interests
m to range throughout the animal king-
m, he has a particular fondness for
wer bees (one of which is resting on his
se in the photo), the focus of his Ph.D.
zoology from Oxford University in
90 (page 22). In addition to studying the
ecies that thrives on the Oxford campus,
has also done research on thermoregu-
ion in twenty-five different species of
wer bees in Israel. Stone is currently a
stdoctoral research assistant in the De-
rtment of Pure and Applied Biology at
perial College in Great Britain. He is
dying the community of insects associ-
d with oak gall, which is invading the
itish Isles, with hopes of finding a bio-
gical control agent. Stone enjoys travel-
g to far-off places, preferably the tropics,
ere he likes to walk at night looking for
imals, particularly large insects. For
ore information on thermoregulation in
sects, the author recommends Bernd
einrich's new book, *The Hot-blooded In-
cts* (Cambridge: Harvard University
ess, 1993)—and for more on the repro-



ductive strategies of bees, *Evolution of Insect Mating Systems,* by Randy Thornhill and John Alcock (Cambridge: Harvard University Press, 1985).

Loren E. Babcock (page 32), who is
ht-handed, became interested in hand-
ness as a doctoral candidate at the Uni-
rsity of Kansas, where he studied mal-
rmations in fossil trilobites. Now an
sistant professor of geological sciences
The Ohio State University, Babcock
ntinues to research the paleobiology and
geography of trilobites and other ex-



tinct creatures. His work has taken him to Bolivia, Italy, China, and to fossil sites throughout North America. His future projects include CT-scan imaging of the brain cavities of ancient vertebrates. For further reading on the fossil record of handedness and its evolutionary implications, Babcock recommends "Trilobite Malformations and the Fossil Record of Behavioral Asymmetry," his article in the March 1993 *Journal of Paleontology,* as well as Harry B. Whittington's *Trilobites* (Rochester: Boydell Press, 1992) and Dean Falk's *Braindance: What New Findings Reveal about Human Origins and Brain Evolution* (New York: Henry Holt and Company, 1992).

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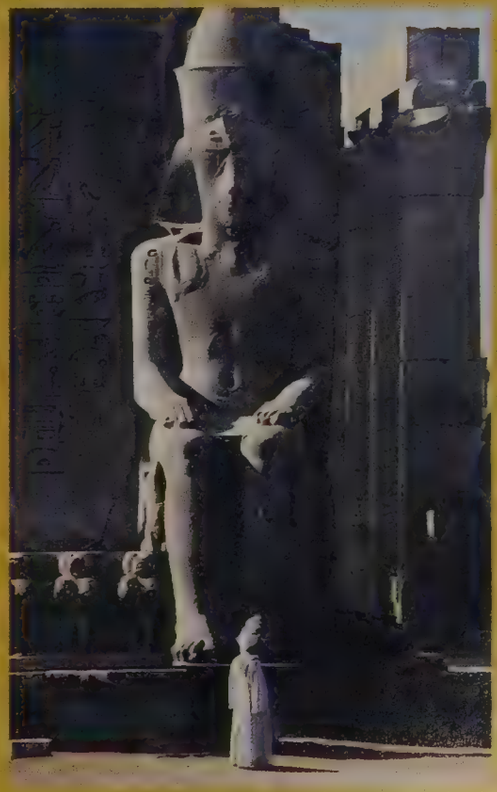
ANCIENT EGYPT AND THE NILE

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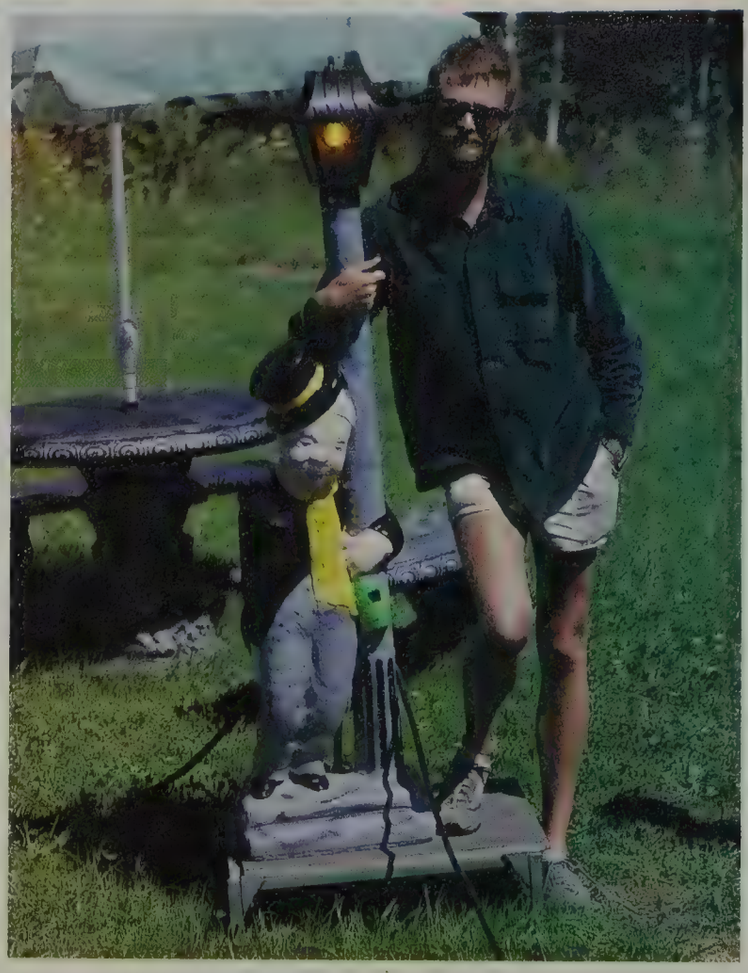
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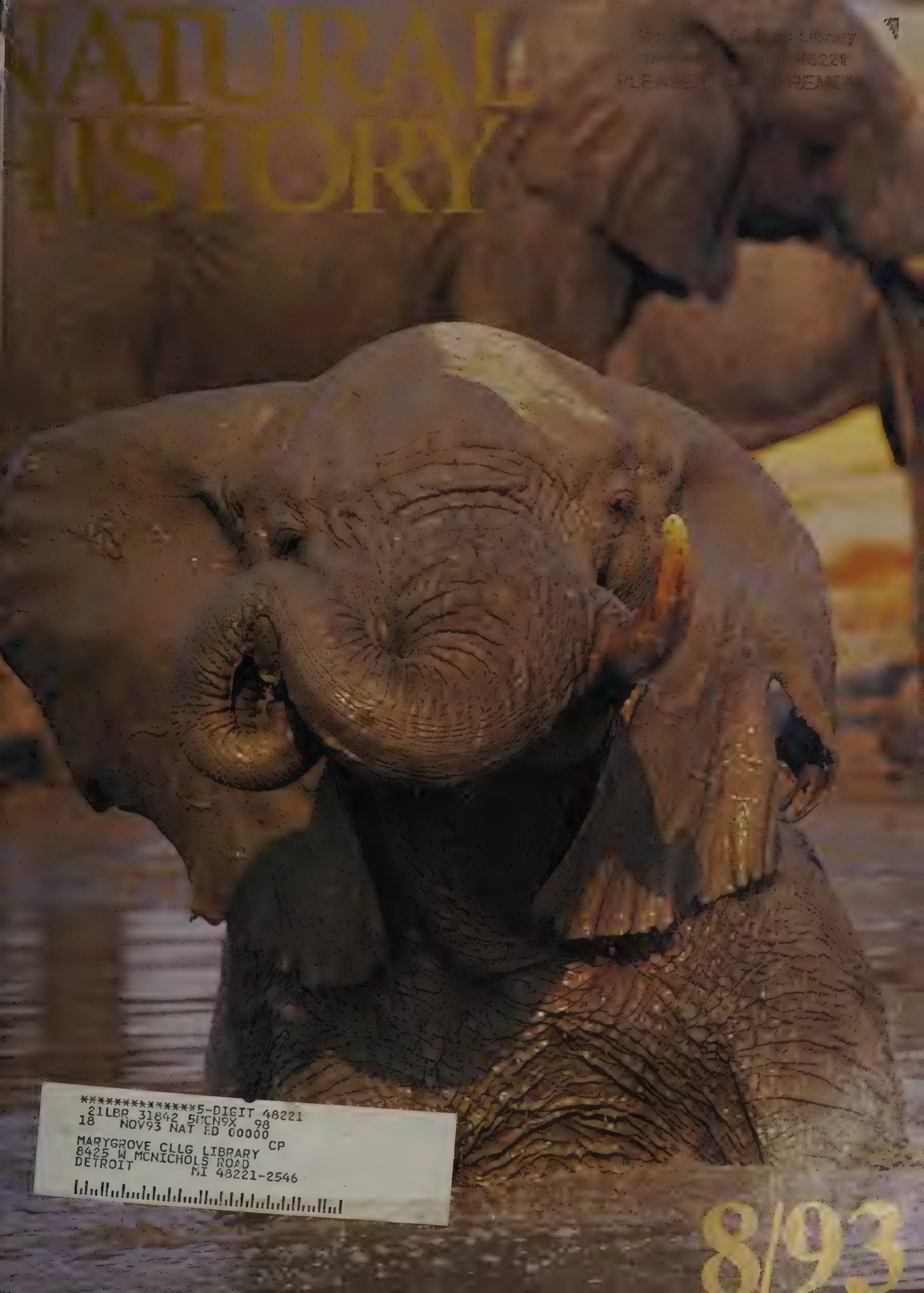
Ian Jamieson (page 50) first became interested in the pukeko's "weird and unusual sexual habits" in 1981, when he attended John L. Craig's seminar on the subject at the University of Alberta in Edmonton, Canada. Jamieson (right), then a graduate student, soon applied for and won a scholarship to do his Ph.D. research on pukeko with Craig at the University of Auckland, in New Zealand. After returning to Canada to a three-year postdoctoral program at Queens University, Jamieson accepted a lectureship in the zoology department of Otago University in Dunedin, New Zealand, where he has continued his research on South Island. Adaptations to his new environment include taking up indoor cricket, which for a Canadian, is "like playing baseball in a squash court." Coauthor **John L. Craig** has taught in the Department of Zoology at the University of Auckland for the past twenty years. An associate professor, he is also deputy dean of science for the university and director of its Centre for Conservation Biology. His current interests include restoration of degraded islands so that New Zealanders will have a chance to see some undisturbed native ecosystems, a privilege now reserved for scientists visiting the most remote islands. Although he still does his DNA research on the pukeko, university administration duties claim more and more of Craig's time. He writes: "I treasure the few days I get in the field each year."





"I spent most of Christmas night 1984 walking the shores of an island Puget Sound, catching birds that had b oiled by an oil spill," relates free-la photographer **Rich Clark** (page 7 "Three of the birds I caught were comm loons." Clark considers himself a gene ist when it comes to photography. He tr els widely on assignment and has p tographed subjects ranging from Budd monks to boxers. This summer, he wil in Iceland photographing gyrfalco Clark took this month's "Natural M ment" from a boat in Ontario's Lake C While his companions fished, he was a to observe and photograph the loon fam for more than half an hour: "The bi were unusually calm, especially for bi with young. They seemed to accept presence without feeling threatened. I l to think of this picture as a thank you that Christmas night in 1984." For shot, Clark used a hand-held Nikon camera with a 400mm f3.5 lens.

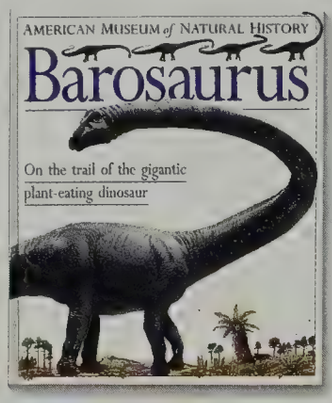


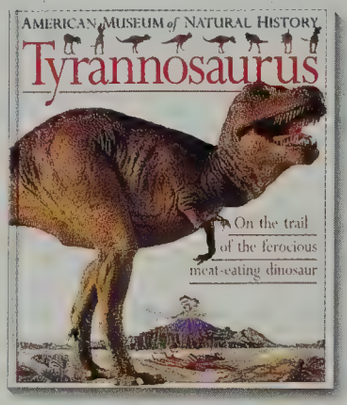


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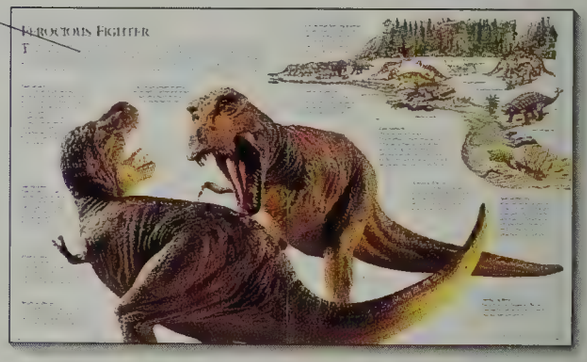




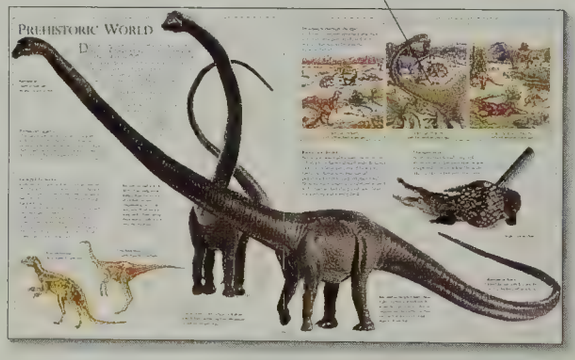
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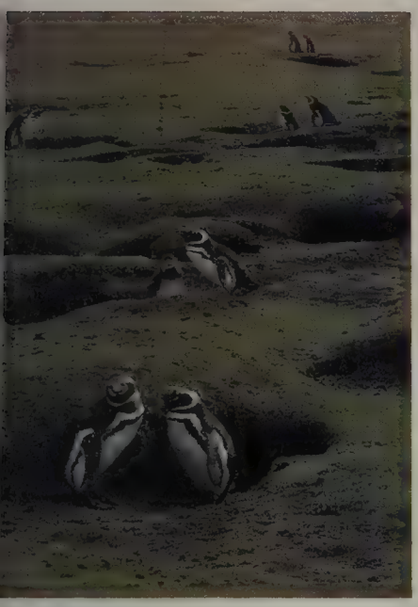
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COVER: *On a hot day in Botswana, even an immature elephant knows that a mud bath is one trick for "beating the heat," the theme of this special issue. Photograph by Beverly Joubert, ABPL.*

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In a special issue for this hottest of months, Natural History *presents a score of articles on how living organisms—including us—evolve, survive, and even thrive in the heat.*

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The Gift of New Questions

By adding the dimension of history, Darwin cooled a hot debate among nineteenth-century scientists

by Stephen Jay Gould

Galileo's telescope was not much superior to a modern birder's field glasses, but he magnified the heavens for the first time and therefore discovered the four large moons of Jupiter, the phases of Venus, and the fine structure of lunar architecture. What could possibly serve as a better example of the dream for which any scientist would kill, die, or sell his soul—an opportunity for pure, unsullied observation of the utterly unknown and the mightily important. In one night, and one peek, the wisdom of a thousand years might be reversed and reconstituted.

Galileo's telescopic observations therefore stand as a paradigm for our primary scientific ideal of objectivity—freedom from the constraints of culturally biased expectation, combined with obedience to nature's factual dictates. After all, you can't be much subject to the shackles of anticipation if you haven't the slightest idea of what you are going to see.

But Galileo also turned his telescope on Saturn—and made a fascinating error that also explodes the beguiling (and self-serving) image of humble and rigorous objectivity. We must approach nature by asking questions of her, and we cannot pose a question without some structure of anticipation. Galileo looked at Saturn, observed the rings as through a glass darkly (for his optics were no great shakes), and thought that he had seen three spheres in a line—a large central body surrounded by two smaller globes.

Following a peculiar custom of his time, Galileo encoded his conclusion in a Latin anagram, which he then sent to his friend Johannes Kepler. (Priority in discovery has always been a touchy issue in science. Seventeenth-century standards were even more fluid and confused than in our own day, and copyright protection scarcely existed at all. Scientists wanted to record their discoveries without fear of usurpation, but with minimal damage should their claims subsequently prove wrong. Hiding a message within a difficult anagram provided a ready solution. With luck, no one would decode the claim properly, and an incorrect hypothesis could therefore remain forever hidden. But if someone later tried to steal your idea, you could publish the dated anagram with your intended solution—and prove your priority.)

Kepler may have been the most brilliant man of his age, but he misread Galileo's anagram as a statement about the planet Mars. Galileo had encoded the following message: *altissimum planetam tergeminum observavi*—"I have observed that the furthest planet is threefold." (Saturn is the most distant of the visible planets; Galileo referred to his misperception of three spheres by designating the ringed planet as *tergeminum*.)

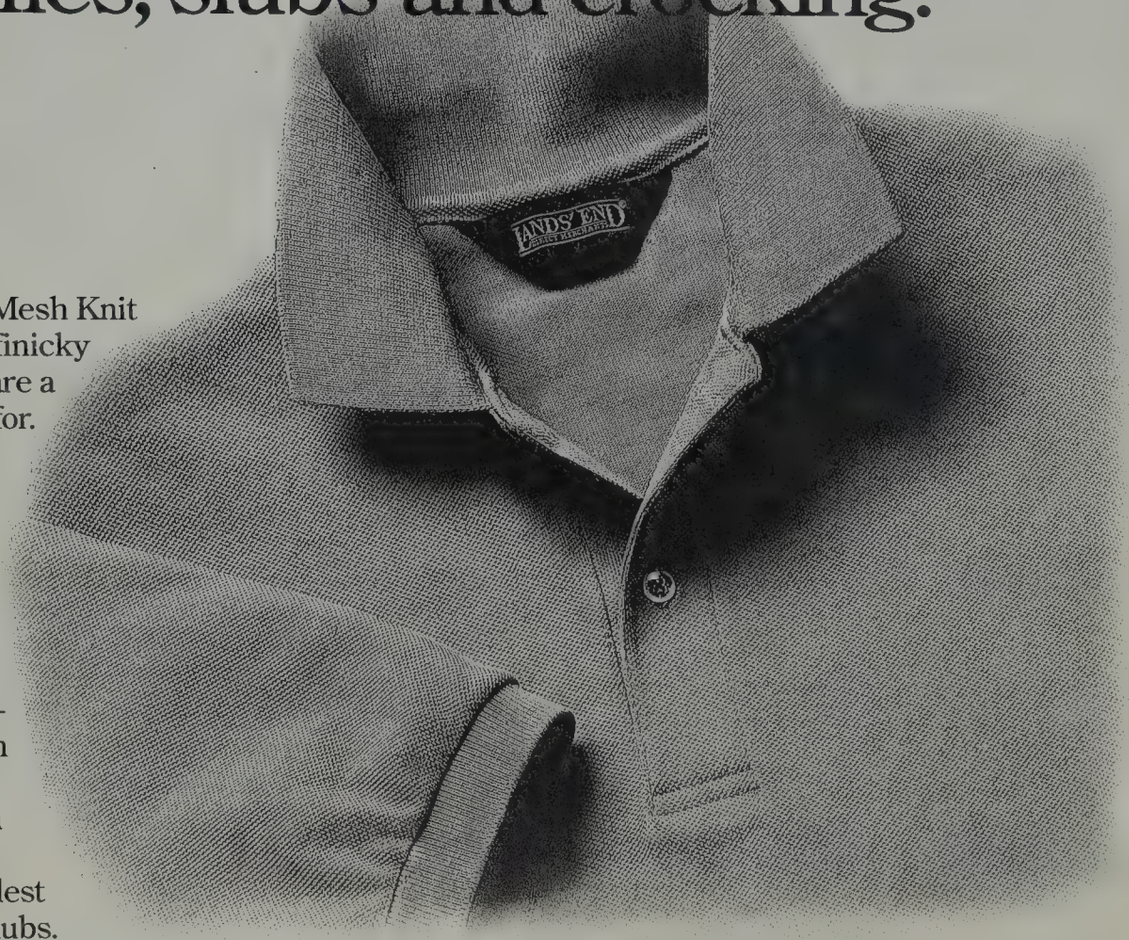
As refutation of a myth, this example has always struck me with particular force. Galileo is so clear and so sure. He does not say "I infer," "I suppose," or "I reason." He states simply: "I have observed"—*observavi*. I have seen it with my eyes, and that is that. But Galileo viewed Saturn through his brain, for we cannot bypass this central focus and filter, this magnificent device crammed full of biases both evolutionarily encoded and socially constructed. I don't think that Galileo had any conceptual space for planets with rings. He was a brilliant and adequately flexible man. Excellent optics might have revealed a ring too obvious to be denied. But Galileo read a fuzzy Saturn in the light of his preexisting knowledge. Planetary masses are spherical. Symmetrical bulges on either side must be subsidiary globes.

All good and useful observation must be embedded within a theory. Scien gains its strength by structuring obser tions as continual tests of a theory's pow Objectivity does not reside in theory-f perception; such a pipe dream can le only to spheres in a line or some oth fancy falsely construed as secure becau we have not scrutinized our constraini biases. Objectivity lies in the flexibility reject a cherished theory when an anti pated observation cannot be affirmed, a a perception of contrary meaning– ringed planet, for example—delights instead.

Theory must guide observation. If do not cast our theoretical net wide enough, we will not see what lies befo our eyes, for the conceptual tools will unavailable to us. This essay tells a sto of observations that could not be made b cause a fine scientist could not formula the theoretical structure that held the rig question. He did not query nature proper and therefore could not see her forms.

In the generation before Darw changed biology forever, most Briti naturalists interpreted the anatomy of an mals as proofs and expressions of Goo wisdom and benevolence. Animals we viewed as marvels of biomechanical d sign, with each feature meticulous adapted in all details to the organism ecology and mode of life. Only an om nipotent God could have created such o ganic perfection. This "argument fro design," or "natural theology"—the infe ence of God's existence and attribut from the products of his creation—ha been the mainstay of British natural hi tory from John Ray in the seventeen century through an apogee in Willia Paley's *Natural Theology* (1802) to a la gasp (more accurately a whoosh) in th eight Bridgewater Treatises of the 1830

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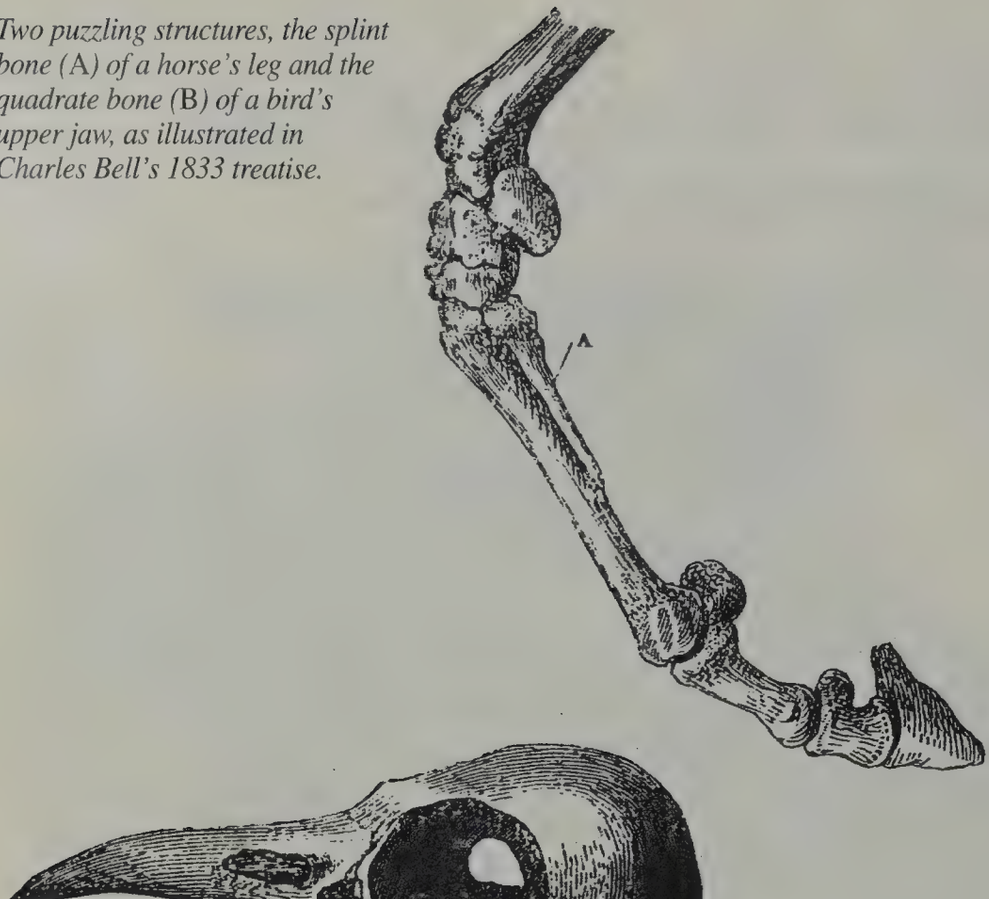
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*Two puzzling structures, the splint bone (*A*) of a horse's leg and the quadrate bone (*B*) of a bird's upper jaw, as illustrated in Charles Bell's 1833 treatise.*

(I have frequently discussed natural theology in these essays if only because Darwin developed his theory of natural selection as a specific refutation of this previous orthodoxy.)

While natural theology dominated in Britain, a very different approach to morphology arose in France and Germany and provoked an interesting debate that the formulation of evolution would later resolve. These "structural," or "transcendental," morphologists tried to explain the differences between organisms as expressions of "laws of form." All animals of a related group can be represented as graded variations of a single archetype. Structures may be reduced, intensified, specialized, or altered in function, but the fundamental relationships of order and position among parts are maintained, and the sequence of changes among organisms follows simple rules of transformation. Thus, the fin bones of a lungfish match the leg bones of a horse, while the jawbones of a reptile may correspond with hearing bones of the mammalian middle ear.

The two schools differed primarily in their attitude toward adaptation. For natural theologians, adaptation served as the basis of organic form. God made organisms with optimal designs for their functions. For structural morphologists, adaptation existed only as a secondary phenomenon, not as the source and *raison d'être* of creation, as the natural theologians insisted. Laws of form and rules of transformation govern the graded series of related animals, and adaptation can represent only a subsidiary fit. Laws of form imply "slots" for certain anatomical arrangements, and animals so endowed must then find an environment to put their forms to good use. In other words, form comes first and must then seek its function. (For natural theologians, function comes first, and God creates optimal anatomies for appointed roles.)

In practice, natural theologians denied graded order and interpreted related animals as functional variations on a common theme. Among mammals with the same bones, some swim, some run, some fly, and some burrow, but no axes of gradation unite these creatures. Each is a paragon of adaptation in its own functional world. Structural morphologists, on the other hand, sought to represent mammals as sequences of gradational changes along a few axes of transformation. The laws of gradation establish the series;

adaptation can only be epiphenomenal a
must often remain far from optimal
constraints of the ordered series precl
tinkering to optimal adjustment).

Theoretical structures can act as mer
prisons when the most productive qu
tion cannot be asked or even conceptu
ized within an accepted world view.
such cases, new theories must break
mental lock, for "pure" observation i
myth and the perception of vital facts
quires the conception of novel questio
In this essay, I will take two puzzles fr
the last great work of natural theology a
show that the factual solution seems
stare the author in the face, yet remains u
perceived as outside the range of questio
that natural theology could ask.

Sir Charles Bell (1774–1842) was
greatest neurologist of his day. His *N*
Idea of Anatomy of the Brain, first pu
lished in 1811, is revered as a foundi
document of the profession. Bell was a
oneer in establishing the fundamental d
tinction between sensory nerves that co
vey impulses to the brain and mo
nerves that send neural messages to
sponding parts of the body. Since the E
of Bridgewater had specifically request
a volume on the "construction of the ha
of man" as a contribution to his endow
series of treatises "on the power, wisdo
and goodness of God, as manifested in t
Creation," Bell seemed an obvio
choice—for he was an artist with words
well as with bodies, and he certainly u
derstood the coordinated functions
brain and hand.

Bell's 1833 Bridgewater Treatise, *T*
Hand: Its Mechanism and Vital Endo
ments as Evincing Design, is the last gre
statement of natural theology applied
anatomy. I discussed this work in my co
umn of March 1993 to contrast Bell a
Darwin on nature's grandeur. In this essa
I will take two specific examples fro
Bell's book to illustrate a question that na
ural theology could not ask, thereby for
closing the possibility of grasping an i
portant side of nature's construction. Wh
other sides are we missing today becau
our theoretical "certainties" preclude t
posing of other fruitful questions?

Bell's book certainly holds the orthod
line on natural theology and the predom
nance of adaptation as illustrating Goo
benevolent creation of the organic worl
Bell begins by writing:

If we select any object from the whole e
tent of animated nature, and contemplate
fully and in all its bearings, we shall ce
tainly come to this conclusion: that there

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design in the mechanical construction, benevolence in the endowments of the living properties, and that good on the whole is the result.

He then continues by stressing adaptation as the primary proof of God's action and intent:

The principle then....is, that there is an adaptation, an established and universal relation between the instincts, organization, and instruments of animals on the one hand, and the element in which they are to live, the position which they are to hold, and their means of obtaining food on the other.... We have seen no accidental deviation or deformity, but every change has been for a purpose, and every part has had its just relation. We have witnessed all the varieties molded to such a perfect accommodation.

Bell explicitly contrasts this adaptationist vision with the structural alternative then gaining popularity in continental Europe. He writes of the opposition:

It is proposed that the same elementary parts belong to all animals, and that the varieties of structure are attributable to the transposition and molding of these elementary parts. I find it utterly impossible to follow up on this system.... I object to it as a means of engaging us in very trifling pursuits—and of diverting the mind from the truth.

He then expresses his perception of trutn in the credo of adaptation and the argument from design: "The function or use of a part determines its form."

As an example, Bell contrasts adaptational and structural approaches for interpreting the two long, thin splint bones surrounding the so-called cannon bone (actually an elongated foot bone) that forms the lower part of a horse's leg. We now know that these splints are vestiges of full ancestral toes. Horses once had three functional toes on each foot (more distant ancestors maintained the full mammalian complement of five). In a classic story of evolutionary change, modern horses reduced the series of three to a single, strong central toe—while vestiges of the two side toes remain as the splint bones, now invisible from the exterior, and making horses effectively one-toed animals.

But this evolutionary solution did not exist in Bell's conceptual world; such an interpretation could not enter his thoughts or inform his questions. For Bell, all features of anatomy required an explanation in terms of immediate, optimal function. He therefore had no alternative but to ask his usual question: All structures exist for a purpose. What, therefore, do the side splints do? When I discover what they do, I will know why they exist.

Bell begins by ridiculing the structuralist alternative—actually correct in this case—that splint bones should be interpreted as part of a gradational series co parable with fully functional toes of oth mammals:

Lovers of system...delight to trace the gra ual subtraction of the bones of the hand. To me, this appears to be losing the sense the love of system. There is no regular g dation, but a variety most curiously ada ing, as I have often to repeat, the same sy tem of parts to every necessary purpose.

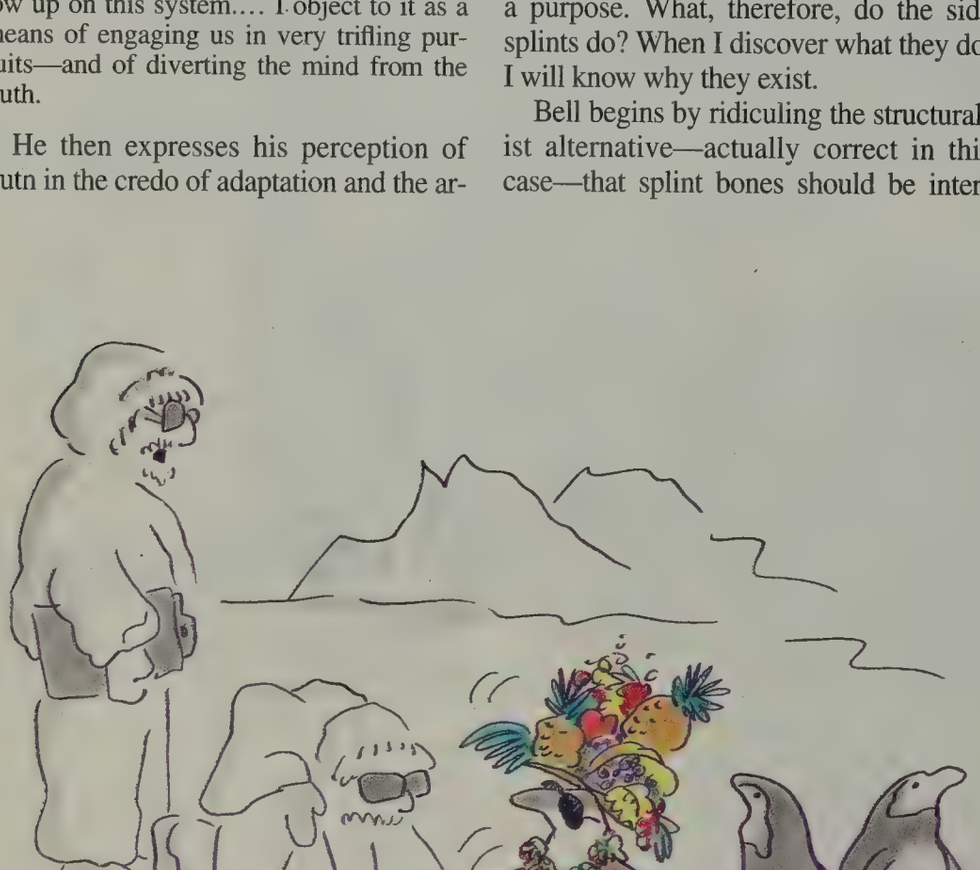
Bell then proposes to prove the supe ority of natural theology by showing th all bones of the horse's foot, including t splints, are exquisite adaptations:

In a comparative view of these bones, v are led more particularly to take notice the foot of the horse. It is universally adm ted to be of beautiful design, and calculat for strength and elasticity, and especial provided against concussion.

Bell's entire discussion then focus upon the search for a functional explan tion of splint bones. He never conside any possible alternative reason for the presence. He cites some disagreeme among experts, but only within the ada tionist paradigm. He states, for exampl that some "veterinary surgeons...imagi that these movable splint bones, by pla ing up and down as the foot is alternative raised or pressed to the ground, besto elasticity and prevent concussion."

Bell denies this view, for he can co ceive of no mechanical means whereb the splints can "add to the elasticity of th foot." He proposes, instead, that the splin "act as a spring to throw out the foot, whe it is raised at the knee-joint bend." But H never asks a crucial question: suppose th the splints are present for a reason oth than optimal function for present pu poses? And you cannot get the right solu tion until you pose a problem within th framework of a proper theory.

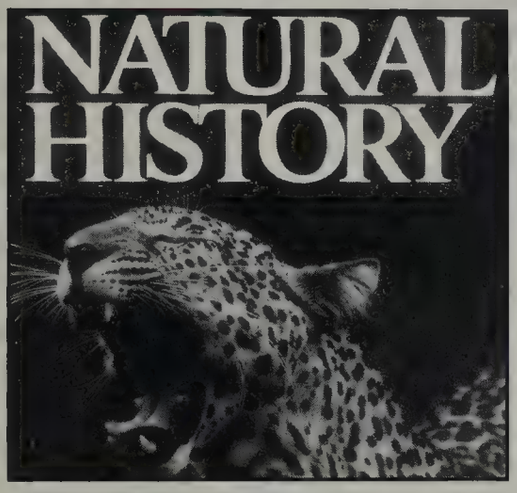
In an even more striking example, Be considers the two small bones (calle quadrate and articular) that form the ja joint in birds and reptiles. Bell confron the following problem: Mammals emplo a strikingly different system by articula ing the jaw between two large bone called squamosal (upper) and dentar (lower), that also form major portions o the upper and lower jaw. (The dentar builds the entire lower jaw in mammal whereas several bones form this structur in reptiles, including the tiny articular a the joint itself.) Moreover—and now th story becomes even more curious—th reptilian jaw-joint bones look suspiciousl like two bones in the mammalian middl



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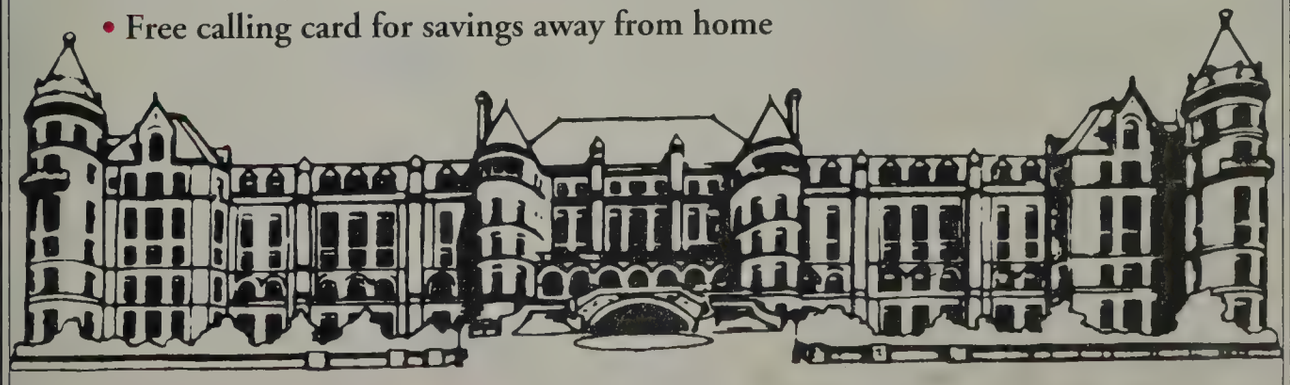


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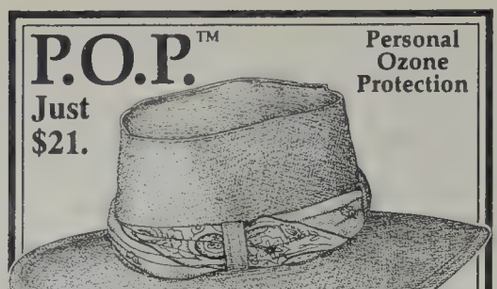
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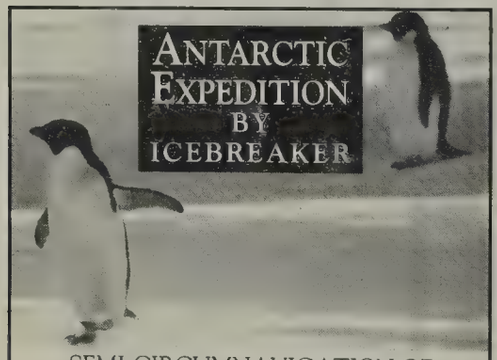
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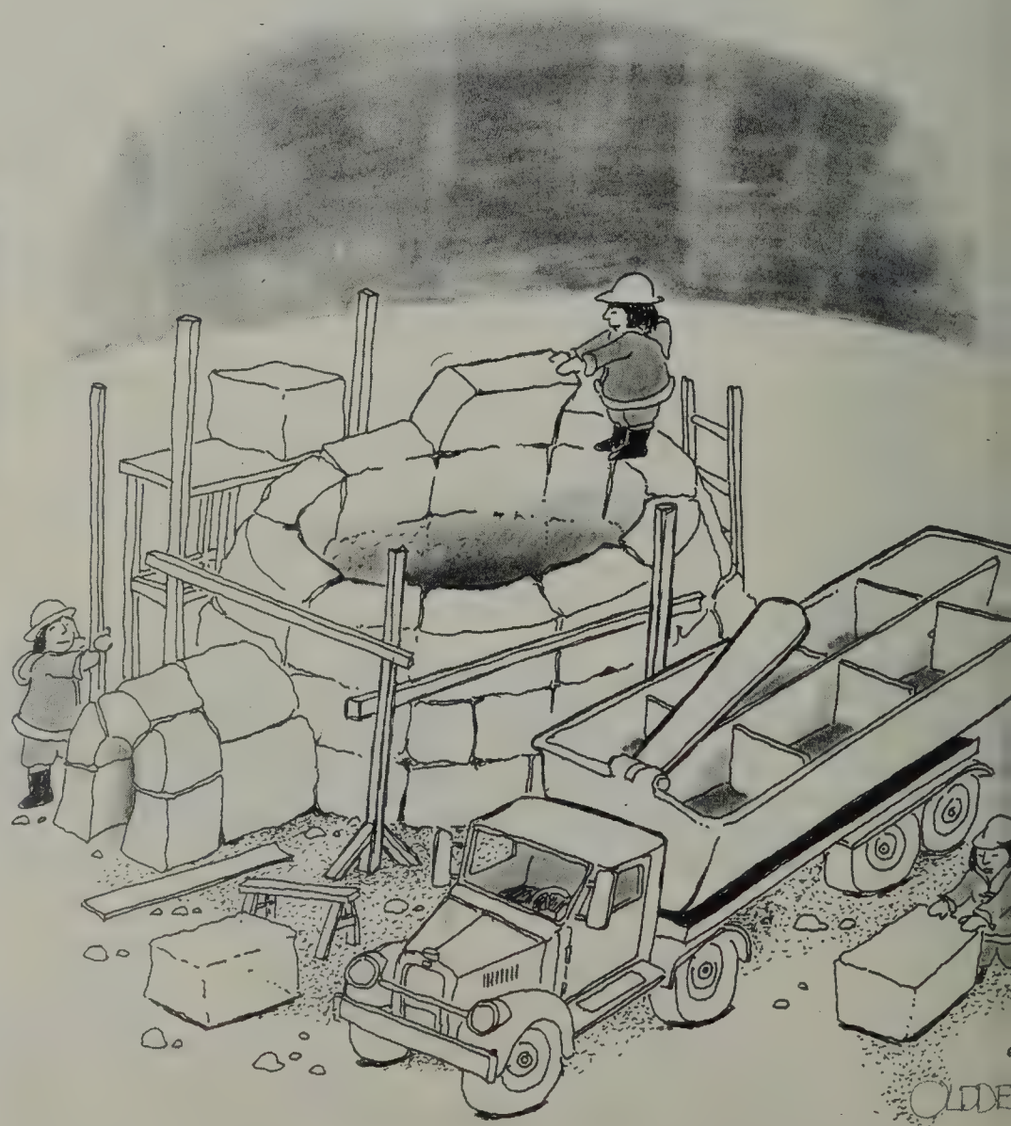
ear, the *malleus* (hammer) and the *incus* (anvil). (The third mammalian hearing bone, the *stapes*, or stirrup, then seems to correspond with the single hearing bone of birds and reptiles.) Bell's nemesis, the continental structural morphologists, had therefore proposed that the jaw-articulation bones of birds and reptiles *are* the same structures as mammalian hearing bones. We now know that this view is correct (but we attribute the differences to historical transformation, or evolutionary change, rather than to abstract rules of gradation among a series of created objects, as most structural morphologists held).

Bell therefore begins his discussion by ridiculing the structural view (now considered clearly correct in this case)—I mean, after all, who could possibly credit such a reverie as comparability between bones of such different function: chewing and hearing. The morphological resemblance can only be accidental. Bell writes of stru tural morphology:

This new theory has been brought forwa with the highest pretensions; the authors it have called upon us to mark the mome of its conception as the commencement of new era! They speak of…"a new princip of connection," and "a new theory of anal sis…." The hypothesis essentially is thi that when a part, which belongs to one an mal, is missed in another, we are to seek f it in some neighboring organ: and on suc grounds they affirm, that this surpasses a former systems as a means of discovery.

Bell then poses the specific problem an pooh-poohs the proposed solution of h enemies:

The matter to be explained is simply this:– the chain of bones in the ear, which is so cu riously adapted in the mammalia to conve the vibrations of the membrane of the tym panum to the nerve of hearing, is not foun in the organ of hearing in birds; but there



stituted a mechanism entirely different. y [the structural morphologists] choose ay that the incus, one of the bones of the in, is wanting in the bird. Where shall we it?—they ask. Here it is in the apparatus he jaw; in that bone which is called *os dratum* [quadrate]. I believe that the ht and accidental resemblance which bone in the bird has to the incus, is the origin of this fancy.

Bell then contrasts this supposed nonse with his own, righteous way. He s once more in ridicule: "Shall we fola system which informs us that when one is wanting in the cavity of the ear are to seek for it in the jaw?" He then sserts the only and proper way to truth: must "on the contrary, take the prine that parts are formed or withdrawn, n a never failing relation to the function ch is to be performed." Finally, in a ement almost eerily reminiscent of ileo's claim for theory-free objectivity ure observation, Bell states that adapon represents evident truth, whereas ctural morphology can only be a mindcking impediment:

only effect of this hypothesis [structural phology] is to make us lose sight of the ciple [adaptation] which ought to direct n the observation of such curious struc-s, as well as of the conclusions to which nbiased mind would come.

n his technical discussion, Bell raises y two points to support his adaptationperspective, and supposedly to deny the jaw bones of birds could be com-ed with mammalian hearing bones:
. Birds hear as acutely with their single e as mammals do with three:

first step of the investigation ought to o inquire into the fact, if there be any imfection in the hearing of birds. That is ily answered—the hearing of birds is st acute; the slightest noise alarms; and nightingale...in a summer evening, will wer to the note of his rival.... The sense earing is enjoyed in an exquisite degree irds: the organ of the sense is not imper-, but is adapted to a new construction, a varied apparatus—suited to the condi-of the bird.

2. The jaw articulation of birds works arkably well for its immediate funcn. Bell points out that, in mammals, y the lower jaw opens and shuts against igid upper jaw, usually fused to the ll—whereas, in birds, both jaws are bile. Bell imagines, no doubt correctly, t this additional mobility has adaptive ue in birds. The bird's jaw, he states,

vithal a fly trap—hence, its motions must apid: and the velocity is increased by the most obvious means imaginable,—that is, by giving motion to both mandibles, instead of to one.

Bell then argues that the presence of two small bones at the articulation aids in this most useful mobility.

Satisfied that he had slain the enemy of structural morphology, with its implication of absent or less-than-optimal adaptation, Bell reasserts the real motive behind his own advocacy—and the Earl of Bridgewater's largess in commissioning, at handsome fees, such a set of treatises on divine wisdom displayed in nature:

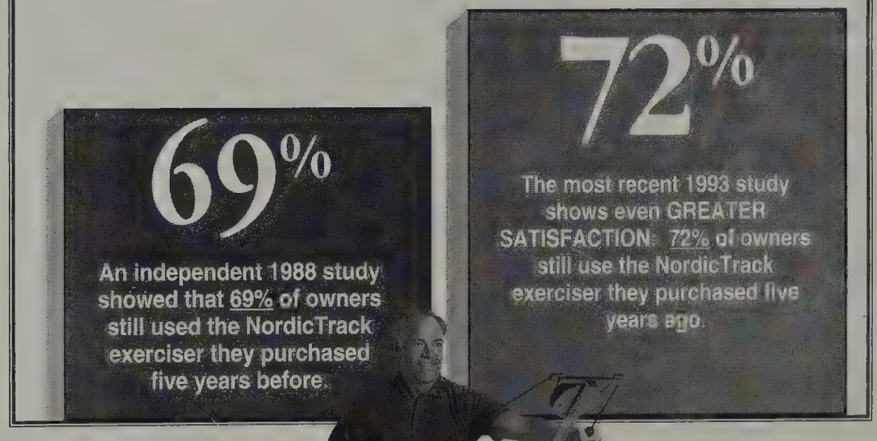
It is, above all, surprising with what perverse ingenuity men seek to obscure the conception of a Divine Author, an intelligent, designing, and benevolent Being—rather clinging to the greatest absurdities, or interposing the cold and inanimate influence of the mere "elements," in a manner to extinguish all feelings of dependence in our minds, and all emotions of gratitude.

Readers may be forgiven for some puzzlement in considering Bell's two arguments for lack of correspondence between mammalian hearing and bird jawbones. From a modern perspective of evolutionary theory, Bell's points are potentially true but entirely irrelevant. Yes, the hearing of birds may be acute; and, yes again,

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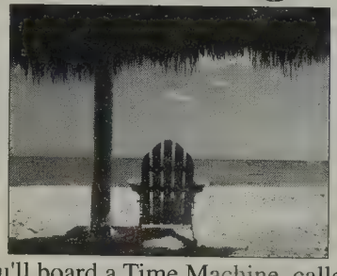
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the two jaw-articulation bones may have eminently useful function. But how do such observations preclude an evolutionary origin for these bones or their later transformation into hearing bones in mammals? After all, the bones may work well in a bird and still be transformed to some other function in a set of evolved relatives. My hands are doing a good job in typing this essay, but their ancestral structures worked quite well for navigation (and still do) in fishes.

We can resolve this puzzle by considering the conceptual limitations of Bell's world—the questions he could not ask and the resolutions that therefore and necessarily eluded him. History and evolutionary transformation did not exist as an option for Bell. In his world, all parts of organisms were created as we find them. Therefore, Bell faced only two possibilities for interpretation: an organ was either created to be used in a certain way or created as one step of gradation in a larger plan for sensible relationships among species. Bell thought that perfection of design proved the former alternative—for creation in the interest of graded order would necessarily fill the world with suboptimal structures, made to hold a place in a series, not to function in intricate and exquisite ways. I Bell's limited world, one need only illus trate excellence of function to prove th adaptationist side of the dichotomy. If th splint bones work well, if the jaw-articula tion bones of a bird do something impor tant, then God must have made them a adaptations for their current use.

Then Darwin stepped in and change Bell's world forever. In the vital style of a intellectual revolutions, Darwin gave sci ence the most precious gift of new ques tions that could not have been posed, c even imagined, before. Just add the possi bility of history and genealogical change and a novel world opens. The old dichot omy—function versus graded order—may now be collapsed into a single, inte grated explanation: a structure may aris for adaptive reasons in an ancestor an then be retained (often in a reduced or ves tigial state) by simple inheritance i descendants. Thus, we may note a grade series, with limited or even absent adap tation in descendants, yet the organ i question may have originated as an opti mal adaptation in the ancestor that anchor the series.

The side splints of a modern horse ma have originated as fully functional toes i



"Why, Zag, you look ten pounds slimmer!"

estors and may now be vestiges of lim- utility, retained by inheritance. An lutionary explanation may—in fact, ally does—include both adaptation gradation. The two warring sides of 's dichotomy are harmonized in Dar- s world. Darwin probably had the side ts of horses in mind when he wrote crucial passage on this subject in the *gin of Species* (pages 199–200 of the edition of 1859):

> by far the most important consideration at the chief part of the organization of y being is simply due to inheritance; consequently, though each being as- dly is well fitted for its place in nature, y structures now have no direct relation he habits of life of each species.... We ot believe that the same bones in the of a monkey, in the fore leg of the e, in the wing of the bat, and in the flip- of the seal, are of special use to these an- s. We may safely attribute these struc- s to inheritance.

find this story particularly compelling ause it illustrates the nub and essence ntellectual revolution in such an inci- , almost joyous, manner. Consider the possibilities of Bell's conceptual do- n as a classic dichotomy—opposite s of single line. His world is one- ensional. An organ is either created for ction at one end of the line, or created step in an ordered series at the other Darwin's revolution is so simple in way, so profound in another: he liter- added a new dimension—the dimen- of history. Darwin freed himself from restricted world of Bell's line: he lifted self above, into a space that did not t for Bell. By adding a dimension of orical change, Darwin realized that an an might arise as an adaptation and , in descendants, be transformed to he other function (jawbones to ear es), or inherited as a vestige of reduced ty (splint bones of horses).

Our literature's best illustration of con- tual revolution as added dimensional- may be found in a great classic of nine- nth-century science fiction—E. A. ot's *Flattland.* The inhabitants of tland live on a surface in a two-dimen- al world. They have no concept of our d dimension or of anything else be- d. They know their own world ade- tely well, though often by means that n inefficient or indirect to those who in a universe of three dimensions. (For mple, Flattlanders cannot "see" the es of objects all at once, and must n which of their members are squares, and which pentagons or hexagons, by feeling their way all around.) One day, a sphere from the world of three dimensions visits Flattland. (He enters by passing through their plane and is therefore perceived by them as a circle that first grows bigger and then smaller.) The sphere eventually lifts the leader of Flattland off the surface of his world into the third dimension, where he can view the entire plane of his former universe all at once. Imagine the thrill, and the confusion, of such a novel perspective!

Darwin added this new, bird's-eye view to the domain of biology. Evolution gave us the dimension of history, thereby enriching our conceptual world through one of the most elegant and beautiful revolutions in all human thought. We are still struggling to make our peace with this new dimension of nature's truth. What else are we missing—what else have we yet to see as we confront multifaceted nature with that genealogically restricted, yet somehow remarkable, tool called the human brain?

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.



"Church bells ring in lofty steeples and echo in ancient streets. The cathedral, bathed in stained-glass light, bids us share in its splendour."



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Pebble Plains, California

by Robert H. Mohlenbrock

The pebble plains in California's San Bernardino National Forest—scattered openings where clay soil is intermixed with particles and small rocks of quartzite—confront plants with a desert-like habitat. Totaling about 550 acres, the plains consist of two dozen patches, ranging in size from one and one-half to seventy-five acres. Additional patches once existed but have been obliterated by human activity, particularly the creation of Big Bear Lake early this century.

Geologist Peter Sadler suspects that the red clay and quartzite pebbles were laid down millions of years ago, during a warmer, wetter period, when the region was relatively flat. Lava flows that overlie some of the clay and pebbles date back six or seven million years—before the San Bernardino Mountains began to uplift. As the mountains formed, the clay and pebbles in some places eroded away or were buried by other materials. Sadler believes that some of the pebble plains are surviving examples of the original deposits, but that others may consist of redeposited sediment. Erosion continues to carry some quartzite pebbles down the slopes of Gold Mountain.





Quartzite rocks carpet Union Flat, below, one of the pebble plains. Lower left: Equipped with gray, hairy leaves to reflect sunlight and conserve moisture, Pursh's milk vetch hugs the ground.

All photographs by Maile Neel



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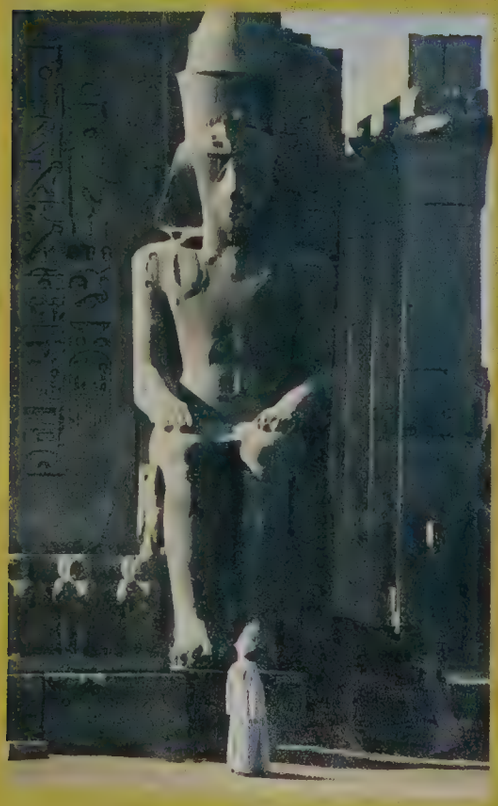
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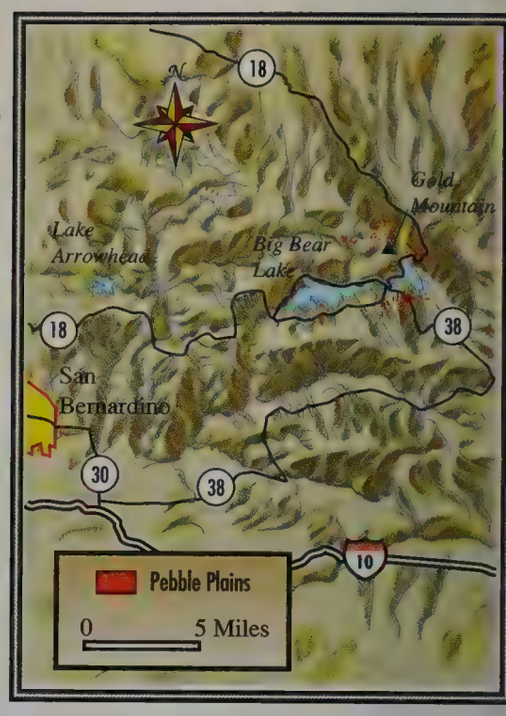
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Because of the high elevation, summer temperatures range from 80° F during the day down to 40° F at night (temperatures drop below freezing at least 250 nights a year). The alternate formation and melting of ice crystals pushes soil upward, bringing pebbles to the surface and creating peculiar, finger-shaped ridges in the clay. Annual precipitation on the pebble plains is ten to twenty inches, mostly falling in winter as rain or snow but with a few heavy summer thunderstorms. Water drains poorly through the fine-grained clay soil, tending to run off or stand in shallow pools. In summer such pools evaporate rapidly, and the land is extremely dry. The reason these areas are not invaded by the adjacent pine forest, botanist Tim Krantz suggests, is that the clay dries out so quickly that pine seedlings cannot survive.

District botanist Maile Neel has recorded forty-five kinds of plants from the pebble plains, one-fifth of them considered rare by the California Native Plant Society. Some of the rarities are known only from the pebble plains, while others are also found some distance away, farther south in California or in Mexico.

Nearly half the plant species on the plains are annuals that flower and form seeds early in spring, then disappear before the onslaught of summer. Among them is Baldwin Lake linanthus, a two-inch-tall member of the phlox family that has creamy-yellow flowers. An annual that blooms later is eye-strain monkey flower, so named because of its small stature and tiny flowers. The monkey flower grows at the edges of seeps, where water from springs crosses the clay and pebbly soil. In the spring, these moist areas are bright



Munz's hedgehog cactus grows in the San Bernardino Mountains and in Baja California.

ble Plains

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n flowers, including yellow violets, insias, and purple rock cresses.

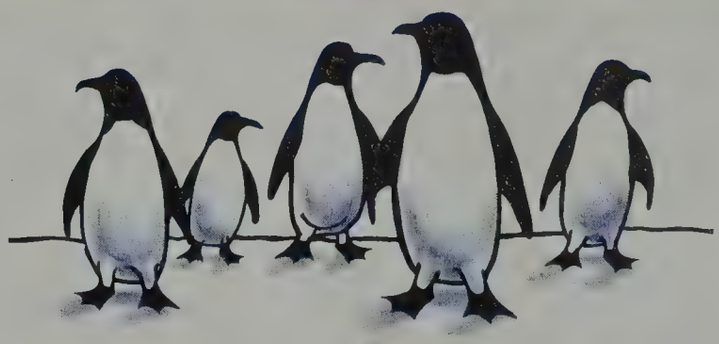
he perennials have developed various ics to withstand the interrelated sses of heat and aridity. Gray, hairy es reflect the sun's intense rays, while serving moisture. Species with hairy es include the Bear Valley sandwort, se small, white, five-petaled flowers ear in June and July, usually following mmer shower. A dwarf member of the ation family, this sandwort is found on y one of the pebble plains and only e. Among the species whose leaves are as well as hairy are Parish's rock s, which is a purple-flowering mus-, and the ashy-gray paintbrush, which greenish yellow flower clusters in its hern range and dull-crimson flower ters in its southern range.

About a fourth of the species are succu-s, which store water in their leaves or ns. An example is Munz's hedgehog tus, found in the San Bernardino untains and in Baja California, Mexico. leaves of some perennials are matted ether in a little cluster that hugs the und. One is the pebble plains buck-eat, found on all the pebble plains en it is the most common plant) and where else. It blooms in July, August, September by sending up a wiry stalk bears a head of tiny white flowers. zy rattail—which grows in the San nardino Mountains and in Baja Cali-nia—is gray, hairy, *and* matted.

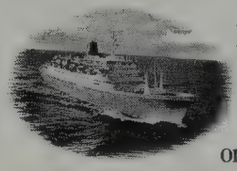
The Forest Service is striving to protect surviving pebble plains. But because are treeless, they are attractive to peo-riding off-the-road vehicles, which d down the plants and leave deep ruts ng rainy weather. Wild burros also n the area, and although they pose a er threat, they, too, trample the delicate etation and rough up the soil, inviting asion by nonnative species.

ert H. Mohlenbrock, professor emeri-of plant biology at Southern Illinois versity, Carbondale, explores the bio-cal and geological highlights of the U.S. national forests.

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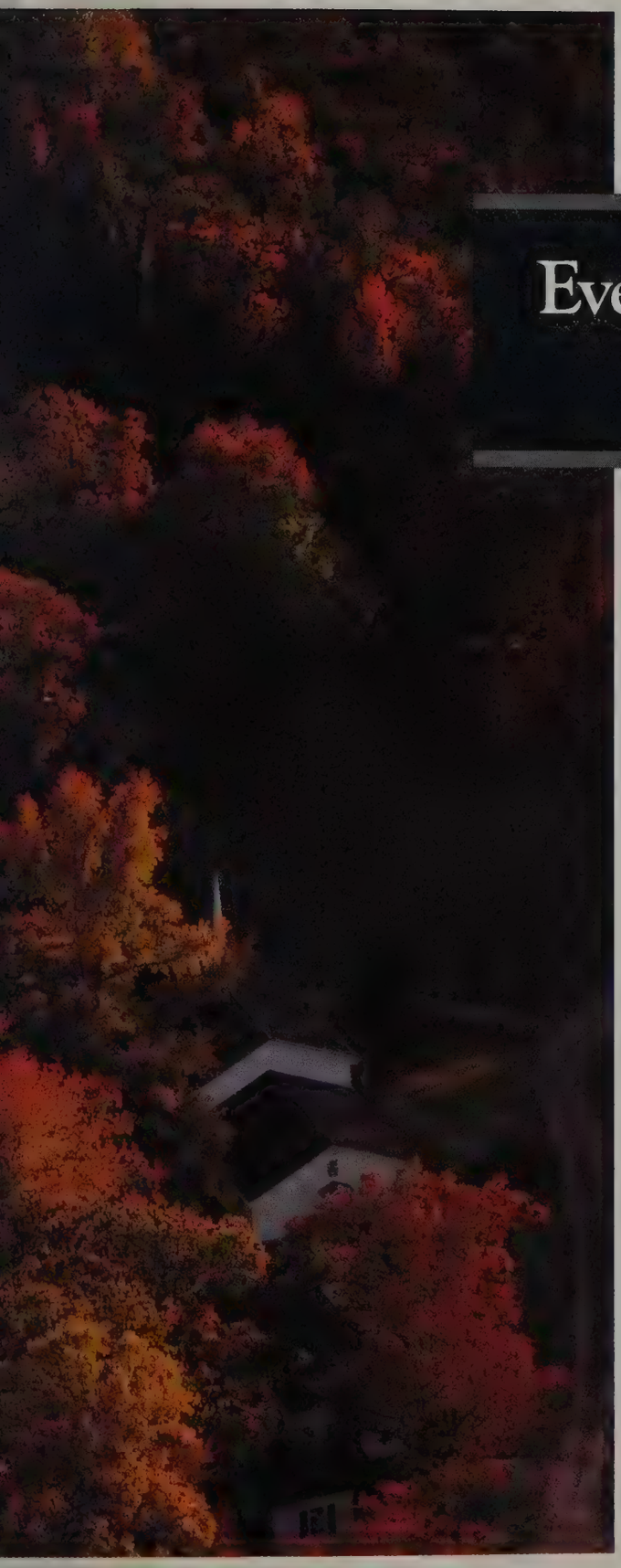
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I N I A

At the American Museum of Natural History

Museum Opens Biodiversity Center

The American Museum has established the Center for Biodiversity and Conservation to coordinate research and develop international training programs in biodiversity and to promote cooperation between Museum scientists and government policy makers, business leaders, resource managers, and nongovernmental agencies.

The Center will coordinate the research of American Museum scientists who survey, inventory, and describe species. While graduate students from around the world already study with Museum scientists, the Center will expand this program to increase expertise in areas where biodiversity is most threatened. Center scientists will also work with other organizations to provide objective data for conservation measures and environmental policy decisions.

Initial funding for the Center has been raised from foundations, corporations, the federal government, trustees, and private individuals. Origins Natural Resources helped launch a corporate campaign by giving a $100,000 challenge grant for the Center, and American Express Publishing Corporation responded with a matching $100,000 grant.

Casbah Dance Experience

The Casbah Dance Experience will present a number of dances from its repertoire, including Raks el Assaya, an Egyptian women's cane dance; and Guedra, a Saharan trance dance of benediction and betrothal. The company's founder and director, Morocco, has spent more than thirty years recovering and preserving Middle Eastern and North African dance forms. The program will take place on Wednesday, August 18, at 8:00 P.M. in the Kaufmann Theater. Call (212) 769-5606 for ticket prices and availability.

Brazil's Forgotten Wilderness

The Pantanal is a vast wetland between Brazil and Bolivia. Home to caimans, capybaras, giant anteaters, armadillos, coati-mundis, and more than 600 species of birds, this lush floodplain was brought to the attention of North Americans when former President Theodore Roosevelt traversed the area to descend the River of Doubt into the Amazon Basin in his 1913–14 expedition. More than 45 photographs from the Pantanal are on exhibit in the Akeley Gallery through Wednesday, August 29.



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A retrospective of Paramount's original 1960s television series "Star Trek" will feature Starfleet uniforms, *Enterprise* models, alien costumes, and assorted props and photos. This exhibition is being shown in conjunction with the Planetarium's new Sky Show, "Orion Rendezvous...A Star Trek Voyage of Discovery," featuring the voice of LaVar Burton as Lt. Cmdr. Geordi LaForge. The Planetarium is open Monday through Friday from 12:30 to 4:45 P.M. and Saturday and Sunday from noon to 5:45 P.M. For show times and prices, call (212) 769-5100.

The Earth as a Peppercorn

The "planet walk" through the solar system will take place on Sunday, August 15, at 1:00 P.M. on the Museum's grounds. Developed in 1969 by astronomer Guy Ottewell, the walk follows a thousand-yard-long model of the universe. Volunteer guide Robert Campanile will lead the tour, which is free of charge and begins on the Planetarium's front steps at 81st Street. Call (212) 769-5566 for more information.

Dancers from Taiwan

For Taiwan's indigenous peoples, music and dance are still an integral part of daily life, woven into religious worship, family celebrations, and the agricultural cycle. Presenting works from the Tsou, Ami, and Peinan tribes, the Formosa Aboriginal Dance Troupe will perform on Wednesday, August 11, at 7:00 P.M. in the Kaufmann Theater. The program is free. Call (212) 769-5315 for more information.

These events take place at the American Museum of Natural History, located on Central Park West at 79th Street in New York City. The Kaufmann Theater is located in the Charles A. Dana Education Wing. The Museum has a pay-what-you-wish admission policy. For more information about Museum activities, call (212) 769-5100.



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Night of the Shooting Stars

by Gail S. Cleere

Shooting stars, or meteors, are common any night of the year; five or six per hour are normal. During a respectable meteor shower, they can be seen streaking across the sky every few minutes. But occasionally the sky explodes in a shower of sparks, a rare event that is something to get excited about. This year we may see such a show on the night of August 11/12 when the Perseid meteor shower peaks. Always the most reliable and impressive shower, the Perseids this year are expected to be spectacular.

Meteor showers occur when cometary debris enters the earth's upper atmosphere at high speed and burns up. All comets, as they orbit the sun, shed material—like a dandelion seed-puff swung through the air. This debris takes the same orbital path around the sun as the comet. We pass through the cloud of cometary refuse whenever the earth's orbit intersects a comet's orbit, which accounts for the annual regularity of meteor showers. The Eta Aquarids in May and the Orionids in October, for example, are the result of material shed from Halley's comet.

The Perseids are remnants of Comet Swift-Tuttle (discovered in 1862) and are named for the constellation Perseus, from which they appear to emanate. These "shooting stars," averaging about fifty per hour, are typically yellow and white, but they can be very bright green, orange, or red. Some leave spectacular trails up to two degrees wide (your thumb held against the sky at arm's length covers about two degrees) and last more than a minute.

This year's display, however, is expected to be exceptional. Not only have the last two years been particularly impressive (indicating that we are passing through a denser part of the orbiting cloud of cometary debris) but last September the Perseids' "parent" comet reappeared, against all expectations. Comet Swift-Tuttle's predicted return in the early 1980s did not occur, and when astronomer Brian Marsden, of the Harvard-Smithsonian Center for Astrophysics, reworked the calculations, he correctly predicted that the comet would return in late 1992. On September 26, it was sighted by Tsuruhiko Kiuchi, an amateur astronomer in Japan. As all comets do when they approach the sun, Swift-Tuttle shed a great deal of material, adding to the orbiting cloud of debris.

Joe Rao—an associate astronomer at the American Museum–Hayden Planetarium—points out that while "the traditional Perseids have been 'laid down' over thousands of years, we have lately entered a region of particles that has been ejected from the comet only very recently, and it is obvious that this material is less dispersed and richer in large particles. There also seems to be a 'knot' of debris accompanying the comet as it moves around the sun." We have been passing through this debris cloud every August for several years, but the exact time of our encounter this year is uncertain.

The calculation of the shower's peak time is a simple one, provided one knows the plane of the orbit of the meteors, because the earth has to intersect that plane. The Perseids, however, seem to be shifting slightly, making a definitive prediction of a peak hour difficult. In any case, according to Rao, the evening hours of August 11, between 6:22 P.M. and 9:15 P.M., EDT, seem the most likely period for the shower to peak. Unfortunately, the former time would not be at all favorable for observers in North America because of solar glare; if the shower peaks at the later time, the sun will have been down for about an hour for those along the east coast of the United States and Canada. But astronomer Gerald Hawkins cautions that "sometimes meteor swarms are above the comet's path, sometimes below, or to the right or left." Given the uncertain position of the plane of the meteors' orbit, viewers would be wise also go out the nights before and after t predicted peak.

Rao believes that this August's Persei may be the show of a lifetime, produci some awesome celestial fireworks, as w the case with the Perseid shower of 186 In addition, he notes that the orbital geo etry of the earth relative to Comet Swi Tuttle in 1993 is very similar to that of t earth and another, smaller comet in 183 In that year, on the night of November observers saw tens of thousands of shoo ing stars each hour.

The constellation Perseus rises abo the northeast horizon after 10:00 P.M., b the meteors will be seen all over the sk The waning last-quarter moon rises abo an hour after midnight on the night of A gust 11/12. Enjoy the show.

THE PLANETS IN AUGUST

Mercury starts out the month as morning object, low in the eastern sky ju before sunrise, not far behind Venus. Me cury is 19° away from the sun on the 4th favorable elongation for observers in t Northern Hemisphere. On the 6th, Me cury passes below Pollux in Gemini.

Venus continues its brilliant perfor ance as a morning planet in August. rises high in the constellation Gemini few hours after midnight and is a good 3 above the horizon just before sunrise. Li Mercury earlier in the month, Venu passes close to Pollux on the 22d. On t 14th, the waning crescent moon makes very close pass just below Venus.

Mars is now in Virgo and can be see setting very low in the west after sunse with bright Jupiter trailing just behind. C the evenings of the 19th and the 20t watch as the waxing crescent moon sai by just below both planets. Mars dives o the western edge of the horizon about or and a half hours after sundown. (A rece NASA report announced that Mars exper

ces frequent quakes—hundreds a year
eater than 3d magnitude.)
Jupiter is also low in the southwest at
ndown, sharing Virgo with Mars.
Saturn rises among the faint stars of
quarius at sunset. At opposition (oppo-
e the sun in the sky) on the 19th, Saturn
brighter than any of the surrounding
rs. On the 3d, the waning moon is just
ove the ringed planet. As Saturn drifts in
29½-year orbit around the sun, the tilt of
rings appears to change. Since late
87, when the northern (top) side of these
gs was at its maximum tilt toward the
th, the rings have been slowly inclining
vard an edge-on aspect, which they will
ch in 1995.
Uranus and **Neptune** are in eastern
gittarius in the summertime Milky Way.
ey rise about four hours before sunset
d set a few hours after midnight. Scan
sky with binoculars just east of the
gittarius "teapot" on a dark, moonless
ght, and with the aid of a detailed sky
p you might be able to spot them.
Pluto can be observed in Libra, but
ly with large telescopes. The distant
net rises about noon and sets about
dnight.
The **Moon** is full on the 2d at 8:11 A.M.,
DT; reaches last quarter on the 10th at
:20 A.M., EDT; is new on the 17th at
29 P.M., EDT; and reaches first quarter at
59 A.M., EDT on the 24th. A second full
on occurs on the 31st at 10:34 P.M.,
DT. Whenever two full moons occur
thin a calendar month, the second one is
led a blue moon. They are rare, occur-
g about once every three years. The last
e was in December 1990, and the next
e will be in June 1996.

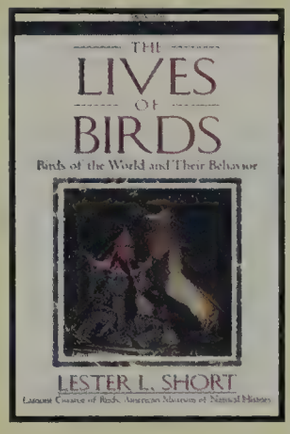
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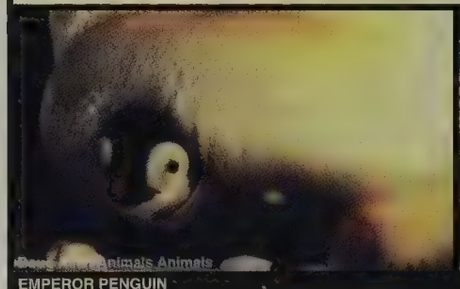
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The Naked Truth

Some friends are unsuited for one another

by Roger L. Welsch

Once, when I was involved in a lawsuit with a neighbor, I attended a meeting between my lawyer and his, who were trying to forge an out-of-court resolution. I watched and listened as they maneuvered, dispassionately sorting through things that I regarded as matters of right and wrong. Finally I couldn't stand it any more. "Your client should be ashamed of himself," I blurted, "acting as if he can take advantage of me anytime he wants." My neighbor's lawyer instantly lost his dignified, professional demeanor: "Don't you talk to me about morality," he snarled. "We know what you do down there on that farm of yours!" He wadded papers into his briefcase and stomped from the office in a fury, slamming the door behind him.

My lawyer and I sat there astonished. The angry man's footsteps were still ringing down the marble hall when my lawyer turned to me and said, "I don't know what you're doing, but cut it out right now before we have trouble we can't deal with." In fact, my lawyer was showing more than just a professional concern: his son was my best friend and was at my farm almost as much as I was. He must have been wondering what wayward paths I had opened to the family scion.

I could not for the life of me figure out what I had done that had driven my neighbor's elderly, sedate lawyer into such a rage. For the next half hour I racked my mind trying to imagine what debauchery I might have missed.

"Okay," my lawyer finally said. "Walk the straight and narrow for a while. I've known Cy for a long time. I'll give him a couple days to cool down and then I'll try to find out what's upset him."

A week later, he called. "Well, I found out what agitated Cy," he chuckled. "The word is out that you guys skinny-dip!"

My tree farm includes a half mile of wooded bank on a lovely, clean river. My farm home at that time was an ancient log house without conveniences—no water, no electricity. Work on a tree farm is hard and dirty; Nebraska summers are uncomfortably hot and humid. For years it had been a part of the usual regimen at the end of the day for everyone—family and friends, whoever happened to be there, tired and dirty—to lug cold beer and towels down to the river for a long, luxurious dip in the cool, clean waters of the gentle river. Men and women. For us it was perfectly normal behavior.

What of propriety? Well, as I have always told my wife, Linda, men are all built exactly alike, and I have no knowledge whatsoever on which to base a physical comparison of women. But that wasn't the point. Neither was the fact that most of us were nearly blind without our glasses, so we wouldn't have been able to see much even if we had looked. The thing is, we skinny-dippers had arrived at a set of tacit agreements about modesty, and that, after all, is what modesty is—a matter of social understanding.

In some cultures, the sight of a woman's nose and mouth are considered irresistibly seductive. In others, the soles of a person's feet are perceived as disgusting beyond comprehension. In mainstream American culture, sex is obscene but violence is television fare for preschoolers. What is acceptable in swimwear is unacceptable in a restaurant. In an elevator we condone contact that would otherwise be actionable in criminal court. Rules of behavior are not absolute; we negotiate them constantly.

At my farm we had reached an unspo ken consensus that at the river, on pr scribed occasions, nakedness was to b ignored. We would have died of emba rassment if someone's pants had falle down at the supper table and, before aver ing our eyes, we had caught sight of boxe shorts with hearts or pink panties wit lace—on the very same bodies we coul have seen completely naked a few hou earlier at the river.

I suppose the chief rule in the canon o Primrose Farm skinny-dipping was sang froid: No staring, pointing, or laughing a lowed. You were to proceed as if yo didn't notice that everyone was naked (Perhaps the only difference was that i normal conversation, one might occasion ally glance, for one reason or another o for no reason at all, below a man's waist o a woman's neck, but during skinny-dip ping, there was a lot more eye contact an gazing off toward the horizon.)

That was never better demonstrate than the time a bunch of us were walkin along a sand bar, naked as jaybirds, wha ever that means. Our custom was to walk half mile upstream, get into the gentle cur rent, and drift slowly downstream ("butt bouncing," we called it). On this occasio we had stopped at the upstream end of th sand bar and were talking vigorousl about something or another when aroun the bend of the bank came two canoes. W screamed and dived for the bushes, cover ing ourselves as much as possible.

After the startled canoeists passe downstream, we gathered what was left o our dignity and sought the safety of th water. It was wacky, we all agreed: Her we were, a flock of academics (almost al of us were anthropologists and folklorists!

o two days later would be dressed for
cess and calling each other Mr. Carter
l Miss Shonsey across office desks. We
re perfectly comfortable with our own
kedness but panicked when we were ob-
ved for an instant by four people we
l never laid eyes on before and would in
likelihood never see again. What was
t all about?!

The canoeists weren't in on the rules,
t's what. They hadn't agreed not to
re, point, or laugh. And they had clothes
another factor in the ethnology of
nny-dipping. The embarrassment of
kedness is particularly obvious when
er people are wearing clothes.

One summer a bunch of friends came to
p me water trees. At the end of the long
y we were hot and dirty, so we headed
ard the river. Six of us were familiar
h the routine; two others were helping
he farm for the first time. The veterans
to the river, undressed, and plunged in.
e male half of the new couple assessed
situation and did the same. His wife
nsidered the process, hesitated a mo-
nt, and put on her swimsuit.

No problem. We were old friends. The
ked folks were all comfortable. After
in the river one is submerged most of
time anyway, so there is little cause for
barrassment. But the woman in the
imsuit was soon visibly troubled. We
l trusted her not to stare, point, and
gh at our fat, skinny, lumpy, warty,
bby, pale bodies…but she had not of-
ed the same trust.

I felt sorry for her in her discomfort but
ln't want to make things worse by call-
attention to her dilemma. My friend—
lawyer's son—swam over to me and
ietly said that he could see she was un-
comfortable and he was considering help-
ing her out. "Have at it," I said. "I have a
feeling she'd be grateful."

"Hey, Dot," John called. "How can you
stand that swimsuit? Mine always gets full
of gravel and turns to lead." And that's
true. The river's water is very sandy.
Shoes, socks, swimsuits worn into the
river soon become sodden sandbags.

"Gosh, that sure is the truth," Dot ex-
ploded, happy to have an excuse other
than immodesty to join our Compact of
Vulnerability. She was naked in moments
and clearly relieved to be a part of our
shared trust.

That, of course, was the foundation of
Lawyer Cy's fury. Those of us who were
naked were neither embarrassed nor pruri-
ent; but Cy, clothed and at long distance,
was troubled by a freedom and trust in
which he couldn't share. He wasn't embar-
rassed nearly as much by our presumed
nudity as he was by his three-piece suit.

And that's what modesty and embar-
rassment are all about. Immodesty, inde-
cency, obscenity are cultural factors, mu-
tually agreed upon and negotiable.
Contrary to the cliché, we don't "know ob-
scenity when we see it"; we decide what
obscenity is, sometimes even without see-
ing it. We are enjoined to "cover our
nakedness," but there's considerable dis-
agreement about what our nakedness is.
Our noses and mouths? The bottoms of
our feet? A lack of trust or mutual respect?

We can talk about it later. Right now, it's
August, it's hot, I won't look if you won't,
and last one in the river is a blue-nosed
lawyer.

Folklorist Roger L. Welsch lives on a tree farm in Dannebrog, Nebraska.

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A tree grows in the harsh Namib Desert of southern Africa.
Jeremy Woodhouse, DRK Photo

Beating the Heat

For life on Earth, heat is a double-edged sword. Too little or too much is fatal. To survive near the hot edge, we hairless, sweating humans have evolved many cultural and physical defenses, especially for protecting our large brains. Other organisms have a wondrous assortment of adaptations against overheating, such as protective waxes, internal radiators, stilts, oval blood cells, and long, vein-filled noses. A few heat-hardy creatures live by hopping and dancing along the deadly edge of the sword. In this sultry month, *Natural History* presents a score of articles on this hot topic.

Death and Dancing on the Sun-baked Dunes of Namibia

by Michael D. Robinson

Shadows cast by the early morning sun highlighted the fresh tracks of a side-winding adder in the sand. Following the marks, I climbed the dune slope to where they ended beside a lar clump of grass. Expecting to find the snake coiled and ready strike, I cautiously circled the grass, searching for signs of t viper's presence, but found none. Frustrated, I removed a pair long forceps from my pack and prodded the clump. Still nothin "Where did it go, and how did it vanish so quickly? It must ha buried itself deep into the root zone," I muttered to myself.

During my three years at the Namib Desert Research Statio I spent many days and nights walking in the dunes nearby. I o casionally encountered vipers side winding across the sand, b never did I find one lurking in the shrubs where I expected it be. One day, however, one surprised me. Seated at the base of dune, I was concentrating on a female *Aporosaura anchietae*, sand lizard endemic to the dune fields of Namibia. Slowly it fo aged along the bottom of the dune's steepest face, where foo often collects. Stopping periodically, it pushed aside the sa with its broad, shovellike snout, searching for seeds from grass



d succulents, as well as for insects and other small arthropods. successful, it continued on. Suddenly the sand above it exded, blurring my vision. As my eyes refocused, I saw the ard violently thrashing in the distorted maw of an adder. Soon was still. The snake unhinged its lower jaw and shifted the ard from side to side, aligning it for its headfirst passage into stomach.

I had seen many species of captive rattlesnakes and Old World ers strike prey, and each time their speed amazed me, but thing had prepared me for the stealth of this attack. Reminisnt of the giant sandworms in Frank Herbert's *Dune* novels, ringuey's adders, *Bitis peringueyi,* can lurk beneath the sand d rise up to engulf their victims. Unlike other snakes, this der's eyes are positioned on the top of its head, allowing the imal to be almost completely buried and still retain a full field vision. Perfectly hidden, the snake is virtually undetectable.

While my research focused on the ecology of the sand lizard, I learned a great deal about the various strategies organisms have evolved to cope with the peculiar climate and topography of the Namib Desert. Compared with other subtropical deserts, the Namib is cool. Its proximity to the sea's cold Benguela current ameliorates the climate. Nevertheless, surface temperatures in the summer can exceed 140° F, surpassing the tolerance of most organisms. Such high temperatures increase the metabolic rate and cause severe dehydration. The desert's shifting sand dunes support very little plant life, which supplies shade and food and is the base upon which all other organisms depend. Here, food is doubly important, for it not only provides energy but is also the main source of water for most desert animals. They must budget their time wisely to obtain sufficiently moist food to offset the energy and water expended in searching for scarce prey.

Heat

Dune topography further exacerbates the situation. The ridges and valleys run north and south, orienting the east- and west-fac-







In the Namib Desert, a sand lizard, left, dances to keep its feet from roasting on the hot sand. A Peringuey's sidewinding adder, top, lies buried in a dune. With eyes on top of its head, the snake can conceal most of its head and body below the surface, where the sand remains relatively cool, as it waits to ambush lizards and other small vertebrates. An adder, above, consumes a sand-diving lizard headfirst.

Photographs by Michael and Patricia Fogden

Heating slopes perpendicularly to the rising and setting sun. Consequently, the east-facing slopes heat rapidly in the morning and the west-facing slopes remain hot until the late afternoon. For animals active during the day, surface temperatures are tolerable for approximately two hours in the morning and three in the afternoon. In the Namib, the amount of time an animal can forage during the day is therefore about half what it might be in a flatter, more vegetated desert.

Some desert animals gain foraging time and avoid lethal daytime temperatures by switching their activity to night, but Peringuey's adder is a real opportunist. I found it to be active day and night in every season, although in summer it clearly favors the cooler night hours. It escapes the extreme daytime temperatures by burying itself in the sand. At a depth of eight inches, the sand temperature does not exceed 90° F. Staying underground also conserves water by reducing evaporation. When necessary, the adder loses heat by rising to a cobralike stance and turning to face the sun. Lifting its body reduces the surface area in contact with the hot sand and promotes cooling the upper body by radiation and convection (such as the transfer of heat via the bloodstream). Facing the sun shades the braincase. In this posture, the adder's vital organs are elevated into a cooler microclimate.

Throughout the year, the sand lizard remains a dedicated day creature, a behavioral rigidity that has its price. In the morning, the dune foraging area has little or no shade. Consequently, the lizard's body temperature climbs steadily, corresponding almost perfectly to the rising sand temperature. Such "thermoconformity" is rare in desert lizards and has been noted in only a few tropical species that inhabit deep forest where sun spots are as rare as shade is in desert dunes. In both environments, the lizards have no choice but to adjust to the prevailing temperatures.

As its body temperature nears 104° F, a lizard must decide whether to seek cooler climes below the sand or forage a little more on the surface. From a physiological point of view, remaining active is a costly proposition that evaporates precious tissue water. With entomologist Paul Cooper, I measured the summer rate of water loss in a number of the sand lizards and discovered that about two-thirds of the individuals sampled were losing more water than they could gain from their food. Because a negative water balance can be tolerated for only a few weeks, the lizard's survival may depend on its finding a juicy insect larva or other arthropod.

Lizards that stay on the surface use three techniques to keep their body temperature below lethal limits. Occasionally, they ascend the dune slope to its crest, and like the adders, they sit upright facing the sun. Any slight breeze removes heat from their skin, and air temperatures at the height of their head and upper body are slightly cooler than the sand. When this is no longer effective, moving to the west-facing slope offers a brief respite. Because of this slope's orientation, the sun strikes it later, and temperatures remain favorable for about one-half hour longer than on the east-facing slope.

When these tactics fail, it is time to dance. The sand lizard's comical thermoregulatory dance consists of raising the opposite fore and hind limbs, leaving the tail and remaining appendages as supports. When sufficiently cooled, the elevated foot and hand replace those on the sand, which then shoot skyward. And so the dance continues, with limbs rising and falling in a jerky, puppet-like rhythm. When dancing no longer abates the discomfort, the lizard dives into the sand and, using its strong forelimbs, swims downward to the cooling depths. Beneath the sand, the lizard breathes by leaving its mouth slightly open. The broad, ove hanging snout prevents sand from entering its mouth.

When I first saw a sand lizard dance, I was reminded of t summers of my youth in Phoenix, Arizona. Defiantly, frien and I would set out barefoot for the nearest swimming pool. reach it we had to cross stretches of gooey asphalt road. O strategy was to sprint the distance; but some days were too h and like the sand lizard's, our burning feet demanded relie Quickly we sat on the road, raising both feet high. When our fe cooled, off we raced with the tarry signature of our thermoreg latory dance on the bottom of our bathing suits.

From Its Blood to Its Hump, the Camel Adapts to the Desert

by Reuven Yagil

Many years ago, I spent several weeks at the Negev Institu for Desert Research studying the effects of water deprivation o the kidney function of camels. The camels had gone witho water for fourteen days. While I had plenty of water to drink, was suffering from the heat and sweating profusely. Even thoug the camels had lost fifty gallons of body water each, they gaze into the distance, serenely chewing their cuds with what I imag ined were contemptuous smiles at my discomfort. Only after I made shade for myself by stretching a sheet between four pole was I able to finish my experiments. The camels appeared to b unaffected by the heat, but it has taken me years of research t find out why.

The ancestors of camels originated in North America 40 to 5 million years ago, but not until land bridges were formed, abou 3 million years ago, did they migrate to other parts of the worl Other cameloid species have adapted to harsh environments— the llama, alpaca, guanaco, and vicuña to the oxygen-poor, col dry air of the Andes and the two-humped bactrian to the arid col of the Gobi Desert. But the one-humped dromedary of the Ara bian and African deserts thrives in some of the hottest and dries climates on earth.

What particularly distinguishes the desert camel is its abilit to relinquish strict homoiothermy and allow its body temperatur to fluctuate according to the rise and fall of the environmenta temperature. In the cool of the night and early morning, camel's core temperature can drop to about 93° F, rising with a

In scorching, waterless terrain, a camel can still cover more than thirty miles a day, traveling at about three miles per hour.
Mike Brown; Oxford Scientific Films





The camel's fatty hump absorbs rays of the sun, protecting the deeper body tissues, while the animal's long, thin legs radiate heat to the air.
Richard T. Nowitz

temperatures during the day to 106° F. As a result, the difference between a camel's body temperature and that of its environment is never as large as it is for other mammals, and so the flow of heat from the air to its body is reduced.

Another of the camel's physiological adaptations to heat is its "adjustable" metabolic rate. Since, in all living things, up to 80 percent of the energy produced by the metabolism of food is released as heat, a warmblooded animal in a hot environment can be lethally endangered by a speedup in internal heat production. The camel's response is to have a slower metabolic rate in summer than in winter—the reverse of most mammals. In addition, dehydration slows a camel's metabolism by triggering a drop in thyroid function. With less thyroxine in its system, the camel's respiratory rate also slows, thereby reducing water loss through the respiratory tract.

When I touched the camel's nasal mucosa, I discovered that it actually felt cool. Every breath, therefore, cools the blood flowing from the nose to the body. This has particular significance for the brain because, in addition to a lowered respiratory rate, the camel, like dik-diks, oryx, gazelles, and other long-nosed animals, as well as a number of carnivores, has a network of blood vessels, called the carotid rete, just below the brain (*see* "A Wonderful Safety Net for Mammals," page 63). The rete insures that when core body temperature is high, venous blood draining th nasal cavity cools arterial blood destined for the brain.

Camel blood is unusual in two ways: it contains more wate than that of other mammals, and its unique, oval-shaped re blood cells stay intact even when the serum, or liquid componer surrounding the cells, is reduced and highly concentrated. Unde similar conditions, the red cells of other mammals would shrive and the blood would cease flowing and transporting body hea outward to the skin, rapidly leading to a lethal heatstroke. Bu even after a camel has lost more than a third of its body water, it blood continues to circulate and dissipate heat.

Such large losses of body water are slow, however, takin place over weeks. The camel conserves fluids by excreting ex tremely dry feces and recycling water from the kidneys to th first of four stomachs and then back to the blood. By contrast, ru minants such as cows and goats cannot recycle water and lose s much fluid when heat stressed that the alimentary tract and kid neys cease functioning entirely. A camel, after recycling its in ternal fluids for weeks, can drink forty gallons of water and re hydrate its blood and kidneys in less than an hour.

To counteract heat and dehydration, the camel also modifie its behavior. If possible, it remains in a recumbent position fo long periods during the day, thus reducing the heat energy pro duced by muscle activity and food metabolism. It urinates on it long legs, and as the urine evaporates, the blood vessels on th legs are cooled. Other coolants—albeit in small amounts—ar nasal secretions that the camel "collects" in a duct between th nose and the mouth.

A camel may be seven feet tall at the hump and weigh more
ın a thousand pounds, so it cannot avoid searing solar radiation
its shelterless, exposed desert habitat. Under such circum-
ınces, however, size is an advantage, since a large object heats
much more slowly than a small one. No matter what the angle
the rays, a camel casts a wide shadow on the ground around its
dy; this shade creates a cooler area into which its body heat
ı be dissipated.

Camels also take advantage of the shade cast by others and
uat close to one another, creating an even larger cooled area.
the same time, each camel faces the sun so that the hump ab-
rbs the most direct sunlight and the smallest possible body
ea is exposed. It will continue to orient itself in this position as
e sun moves across the sky.

The hump is a concentration of body fat that acts as a kind of
otective cover, shielding the animal's vital organs in the deeper
ers of the body because it slows the conduction of heat. I have
ticed that as the mass of fat heats up, the hump actually feels
t to the touch. The rest of the camel's body has very little in-
lating fat, and therefore extra body heat can be transferred
ore quickly to the environment, particularly through the
mel's extremely thin legs. This is similar to the way in which a
ck rabbit loses heat through its ears or a cow through its
wlaps.

Thus the camel, in its many adaptations to extreme heat and
yness, relinquishes its need for water-dependent cooling
echanisms, while I, the scientist, in order to study the animal,
quire shelter and abundant drinking water. □

When the Going Gets Hot, the Tortoise Gets Frothy

y John Cloudsley-Thompson

Abdel Gadir was the first of my baby African spurred tortoises
d I treasured him accordingly. Thirty years ago, when I taught
ology at the University of Khartoum, we kept a number of
ese desert tortoises, the world's largest mainland species.
nly the Galápagos and Indian Ocean island giant tortoises can
o them.) In November 1965, one of our females laid seventeen
gs, of which only one hatched the following June. Our Su-
nese laboratory staff named the baby Abdel Gadir, or "servant
God" in Arabic—a common nickname for tortoises.

Until we could make a proper enclosure, I used to put him on
e lawn to graze on the small, succulent shrubs that he evidently
eferred to the grass that his parents ate. In order not to lose him,
confined him beneath a clear plastic microscope cover in the
ade of a palm tree. One day, on my way home to lunch, I re-

membered that I had forgotten about Abdel Gadir. I dashed back to find that the sun had moved and he was no longer in the shade! Indeed, the poor little creature was extremely hot, and frothing all over his head and neck. I took him into the laboratory, gave him a drink, and went back to lunch. On the way, a thought struck me. When jerboas and kangaroo rats get overheated, they salivate onto their throats; this cools them and can prolong their life, in an emergency, for up to thirty minutes. (Small mammals cannot afford to cool themselves by sweating and do not possess sweat glands.) Could tortoises respond in a similar way?

The next day, Abdel Gadir found himself in an incubator at 131° F. He was removed every thirty minutes to be weighed and have his body temperature taken. During the first hour, his weight decreased only slightly but his temperature rose from an initial 77° F to 105° F. At this point, Abdel Gadir began to salivate and froth at the mouth; his temperature stabilized, but he began to lose weight rapidly. After another hour, I took him out and gave him a drink of water. He soon recovered and seemed to be none the worse for his experience. Spurred tortoises do not normally drink, for they obtain sufficient moisture from their vegetable food. After salivating, however, Abdel Gadir, and all the other tortoises that I tested, enjoyed a good long drink.

In 1969, I was at the University of New Mexico, in Albuquerque, where physiologist Bud Riedesel, my wife, Anne, and I were testing the responses of ornate box turtles to heat. These turtles also used evaporative cooling—not only by salivating but also by urinating on their back legs. We found that the heartbeat rate increased only when the body temperature increased, but that salivation could be induced by heating the head alone.

If you think that box turtles are pleasant, docile animals to work with, you are mistaken. They have a well-developed hinge midway across the length of the lower shell that enables them to enclose the head and extremities. After a heat-measuring thermocouple was inserted into their rectums a few times, they objected to future tests by snapping their shells closed. If we were not careful, we got our fingers pinched hard. Also, they became exceedingly wary. We had to creep up on them and wedge a cork between their shells to keep them from closing.

That was not the end of their revenge for our experiments in temperature regulation. Like other land turtles and tortoises, the box turtle is endowed with a very large bladder that has several functions. It can be used for emergency cooling, as well as to store water for use during long periods of drought, hibernation, or estivation. But it also emits a foul smell that is an effective deterrent against predators. We soon learned that when picking up a tortoise, you always want to keep its ventral side pointing away from you!

Since our early investigations, a great deal of research has been undertaken on the ways in which tortoises and land turtles of various species regulate their body temperatures. In addition to the considerable insulation provided by their top shells, they cool themselves through salivating and frothing at the mouth, urinating on the back legs, moistening of the eyes, and panting. Another way in which they achieve thermoregulation is by varying the heart rate according to body temperature and by dilating the peripheral blood vessels in response to heating.

Animals can be categorized by the major source of their body heat: endotherms, which warm themselves mainly by metabolic processes, and ectotherms, which depend upon external heat from the environment. Reptiles are ectothermal: they regulate their temperatures largely by their behavior. When presented

Heat with a choice, tortoises and turtles may select exposed logs or rocks, where they bask until their bodies reach the preferred temperature. From their behavior, it appears that the optimal temperature for metabolism must be surprisingly close to the critical upper temperature at which the animals seek shade.

After basking, land and desert tortoises retreat into cool burrows. Not infrequently they emerge again in the evening and continue to bask until the sun begins to set. In general, they lead a leisurely existence, getting up late and retiring early. At the time of midday retreat to the burrow, the temperature on the top shell of the American desert tortoise may be as much as fifty degrees above the deep body temperature. Both heating and cooling rates are affected by thermal gradients between the core of the animal and the temperature of the environment.

Some years ago I worked with nuclear physicist David Butt on Mediterranean spur-thighed tortoises. These tortoises live on the fringe of the Sahara where they estivate during the hottest part of summer and hibernate in winter, becoming active only in the spring and fall. When we measured metabolism and evaporation at different air temperatures, we learned that up to about 75° F, the metabolic heat gained and evaporative heat lost were about equal. At higher temperatures, however, evaporative heat loss could not keep pace with metabolic heat production. These experiments led us to speculate that with the advent of seasonal climates 60 million years ago, hot summers rather than cold winters might have had something to do with the demise of dinosaurs. Our calculations showed that large size would have been a useful strategy for reptiles in a stable, moderately warm climate, but higher temperatures were likely to cause severe thermal stress.

During our work on temperature physiology, one of the tortoises ate the cobalt thiocyanate paper used to monitor humidity, defecated over the temperature sensors, and blocked the entry port for air, so that it nearly suffocated. "We certainly have technical problems in physics research," my partner from the "hard sciences" commented, "but never have I experienced anything like this!" □

The African spurred tortoise, right, which can weigh 180 pounds or more, digs shallow burrows to escape the heat. Found along the southern fringes of the Sahara, it is named for its strong tail spurs. Below: The ornate box turtle lives in Texas, Nebraska, and southern South Dakota. A hinge on its lower shell allows it to snap closed when the animal is disturbed.

Rod Planck; Photo Researchers





Plants Stand on Stilts above Australia's Scorching Sands

by John S. Pate

On a summer day, you can fry an egg on the scalding sand flats of southwestern Australia, yet thousands of small plants manage to live there. Intense sunlight raises ground surface temperatures to between 122° and 158° F, and the upper soil dries out completely. How do plants survive such conditions? Some avoid going through their vulnerable stages in summer, remaining buried as dormant seeds that germinate only during the cool, wet winter and spring. Others shed their above-ground parts and survive underground as tubers or bulbs. Still others—known as resurrection plants—dehydrate to brittle, dead-looking clumps of curled leaves that unfurl, become green, and resume photosynthesis with the first rains of autumn. Many small perennials, however, can retain green leaves right through the summer by raising themselves off the ground on stiff, aerial "stilt roots." These "stilt plants" seem to have evolved independently among several lineages of unrelated plants, including diminutive members of the lily, kangaroo paw, sundew, and trigger plant families. Within some genera, the only known species are stilt plants; but of the 160 Australian members of the Southern Hemisphere rush family, only one grows on stilts.

Stilt roots provide a tiny but critical increase in altitude that makes a world of difference to the plants. Each shoot thrives one-half to one and one-half inches above the surface, where daytime summer air temperatures are from 10° to 18° F cooler than the ground. So lethal is the hot soil that plants die if their stilt roots are covered with it, as experiments have shown. When undisturbed, however, they enjoy survival rates of 80 to 100 percent.

Stilt plants have other adaptations to the high heat. The lower portions of aerial roots are covered by thick, dense fibers that insulate the delicate inner tissues. In some trigger plants, for example, the phloem tissues, which conduct sugar and other nutrients, are in the middle of the root, surrounded by the dead, water-conducting cells, or xylem. In most plants, the positions of xylem and phloem are reversed. Below ground, parts of the stilt roots penetrate deeply to provide water to the shoot throughout the summer.

More than a hundred species of southwestern Australian plants have developed stilt roots, as have a few other species from the dry northern and eastern parts of the continent. Most of the southwestern species are between an inch and one-half and five inches tall, have leaves arranged in compact rosettes, and



Just after the first rains at Cannington Nature Reserve, Perth, a four-year-old trigger plant sprouts new leaves about two and a half inches above the sand.
John S. Pate



grow only during the winter wet season—although they remain green right through the summer. A few stilt plants, including one from the swampy margins of the Queensland rain forest and some from the southwestern Australian wetlands, inhabit areas that are prone to seasonal floods. There the stilt roots enable them to avoid drowning as well as to endure high temperatures.

Heat

Stilt plants vary widely in their structures and means of reproduction. Some have compact shoots, some climb on leaf tendrils, and others spread by above-ground root mats. Smaller species of so-called tile-leaf trigger plants have tiny, densely packed leaves that adhere closely to their stems for protection against dessication. Stilt sundews reproduce clonally by means of pinhead-sized gemmae, which form each autumn in a cup-shaped structure at the top of the shoot. Raindrops splash the gemmae out of the cup, and new plants quickly form, growing stilts by the end of their first season.

Seedlings of stilt plants are at first no different from most other plants. As they grow, however, their aerial stilt roots form, the seedling's original root and lower stem die, and the young shoot thus becomes permanently elevated. Each winter season, one more set of stilt roots develops. Because their growing shoots are all exposed above ground, all species of stilt plants are susceptible to the heat and smoke of fire. However, during the first autumn after a fire, seeds stored in the soil from the previous years germinate en masse, although only very small proportions of these are likely to survive the first summer.

As far as we know, the stilt adaptation is rare or nonexistent among small plants in Mediterranean climate ecosystems outside Australia. There are none in Europe, California, Chile, South Africa, or other arid areas where rain falls entirely during the summer or biyearly. In most of these ecosystems, ephemerals (winter or summer annuals), leaf succulents, and rock-living plants predominate. Why such prolific development of stilt plants has evolved only in Australia remains unanswered. □

In the Sonoran Desert, Cicadas Court, Mate, and Waste Water

by Eric C. Toolson

A midday walk through the Sonoran Desert on a typical summer day can be enervating. The shade temperature shoots up to 105° F well before noon, and the sun is relentless. To keep cool, you must sweat profusely, and to replace lost fluid, you will need to drink about a half gallon of water an hour.

You are not alone in your suffering. Even the plants are hunkered down against the onslaught: deciduous species such as

Heat mesquite and paloverde have lost their leaves, the creosote bushes have a sickly yellowish tinge, and the cactuses appear gaunt and shriveled. Flowering annuals that cloaked the landscape with color earlier in the spring have long since died, entrusting their fate to the hardy seeds they produced during the brief growing season.

Signs of animal life are difficult to detect. Birds gave up singing hours ago, and no lizards scurry about. The only clue that animate creatures are thriving here at all is an unmistakable sound: the omnipresent, high-pitched buzzing of singing male cicadas. These cicadas, *Diceroprocta apache,* abound in the mesquite and paloverde trees. Incredibly, they are courting, mating, and ovipositing in heat so inhospitable as to force virtually every other life form into some sort of refuge. How are cicadas able to stay cool enough to be active under such conditions?

The answer to this question came from some unexpected experimental results during my early work on the physiology of cicadas and from follow-up experiments with Neil Hadley and Michael Quinlan, both of Arizona State University. When threatened with overheating, cicadas extract water from their blood and transport it through large ducts to the surface of their body, where it evaporates. In other words, cicadas keep cool in essentially the same way heat-stressed people do: by sweating!

Until our discovery, sweating as a cooling mechanism was known only in humans and a few additional mammals. Its presence in any other animal was completely unsuspected. No other insect, including the cicada's closest relative, the leafhopper, possesses the ducts required for sweating.

The ability to sweat varies among cicada species and reflects the number of ducts in its shell, or cuticle. In hot-desert species, such as *D. apache,* the ducts are abundantly distributed across the upper surface of the body. Correspondingly, the cicada can reduce its temperature by as much as ten to fifteen degrees below that of the surrounding air—a remarkable amount of cooling for any animal. Species from cooler habitats, such as the thirteen- and seventeen-year periodical cicadas so familiar in the eastern United States, have only a scattering of sweat pores and cannot significantly reduce their body temperature by sweating. However, their habitat contains thick deciduous forests, so adults can usually avoid overheating simply by moving into the shade. Cicadas that are nocturnally active during cool seasons in alpine forests of Tasmania and southern Australia apparently lack the pores entirely.

Sweating allows some cicada species to remain active under heat conditions that are intolerable for their enemies, such as predatory birds, lizards, small mammals, and the provisioning wasps known as cicada killers. Why haven't some of the many other insect species that are found in extremely hot environments evolved the same ability?

Probably the main reason is that most small organisms cannot afford the extremely high rates of water loss required for effective evaporative cooling. *D. apache,* for example, must lose 20 to 35 percent of its body water each hour in order to stay cool at the air temperatures (110°–115° F) it routinely encounters in its habitat. To put this into perspective, humans die if they lose more than 7 to 10 percent of their body water, and most insects cannot tolerate losses of more than 15 to 20 percent.

Cicadas, however, can afford the luxury of losing water because they feed on the xylem fluid of plants. This liquid provides them with much more water than they need. Anyone conducting field studies under trees containing large numbers of cicadas experiences a constant light "rain"—actually the rectal fluid the cicadas expel to unload excess water—that often soaks field note and besmears camera lenses and eyeglasses.

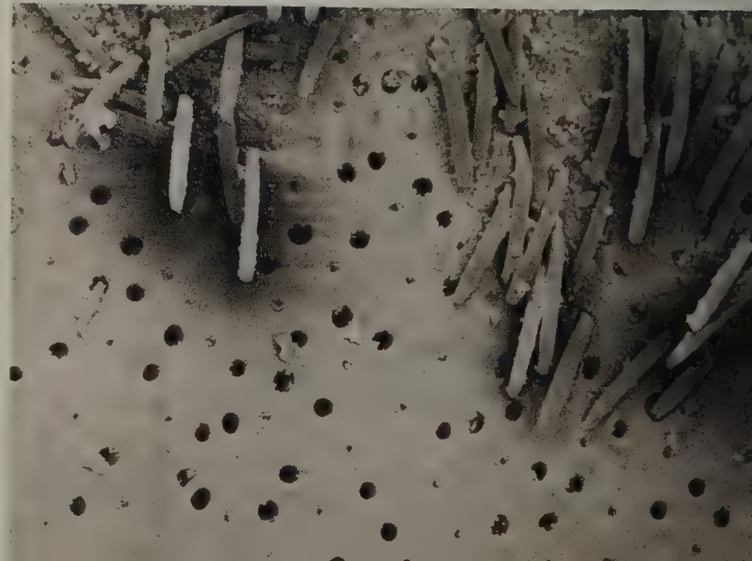
A cactus-dodger cicada rests on the trunk of a cholla cactus in the New Mexican desert. The insect has a well-developed sweating system.
Eric C. Toolson

Thus, cicadas are the exception to the conventional wisdom about how animals adapt to life in hot deserts, where elegant water conservation mechanisms are the rule. Contrary to most experts' expectations, *D. apache* and other hot-desert cicada species lose water faster than any other insect known.

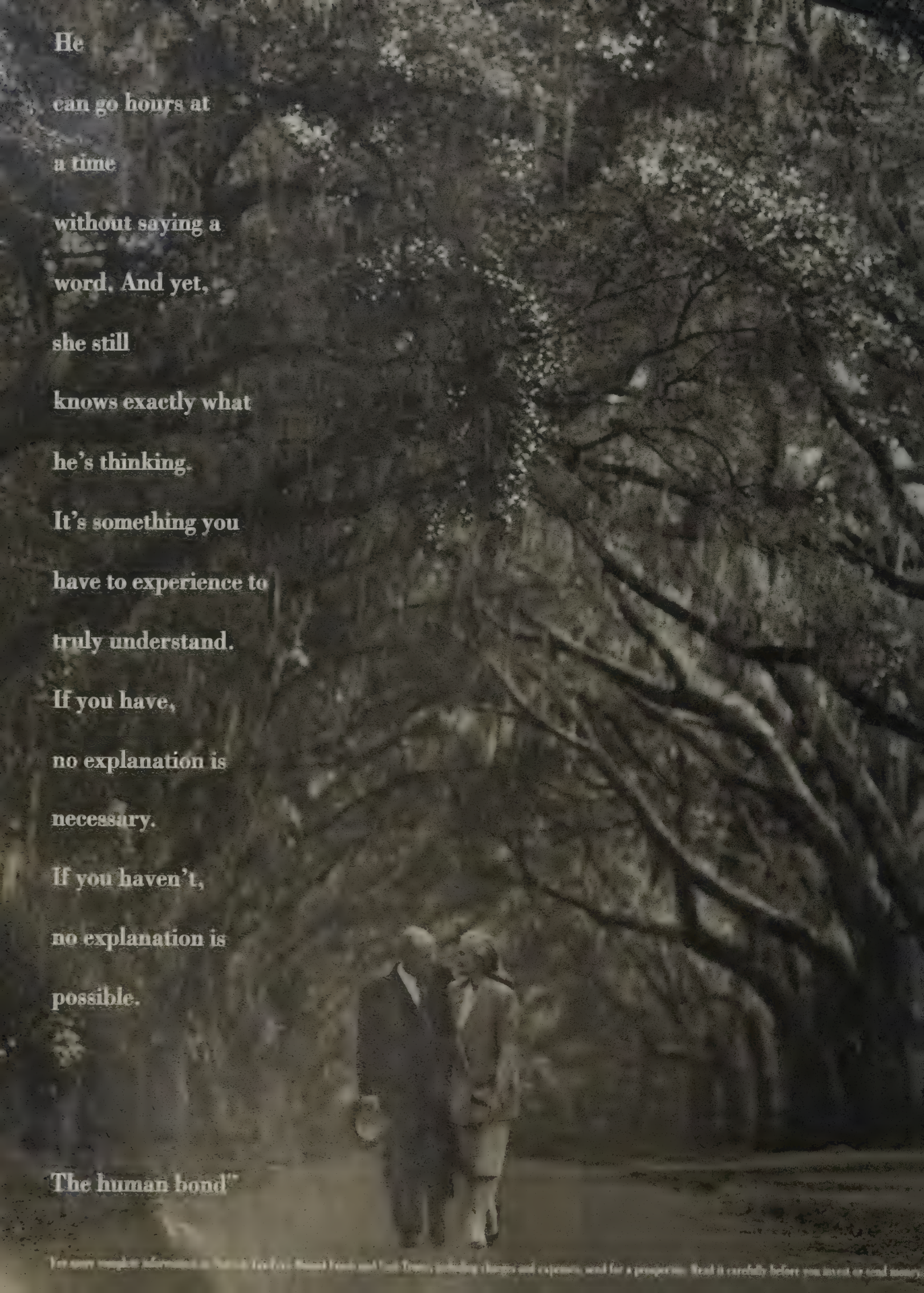
Access to abundant water was undoubtedly an essential key in the evolution of sweating by cicadas. Did a long-ago "choice" of xylem fluid as a food source put them on an evolutionary path that subsequently conferred special advantages in adapting to hot environments? Support for this hypothesis comes from the high water-loss rates exhibited by other hot-desert insect species such as cactus-breeding *Drosophila,* whose food source also contains abundant water. Another question is, was sweating well developed in ancestral cicadas or did it evolve later as they invaded hotter, drier environments?

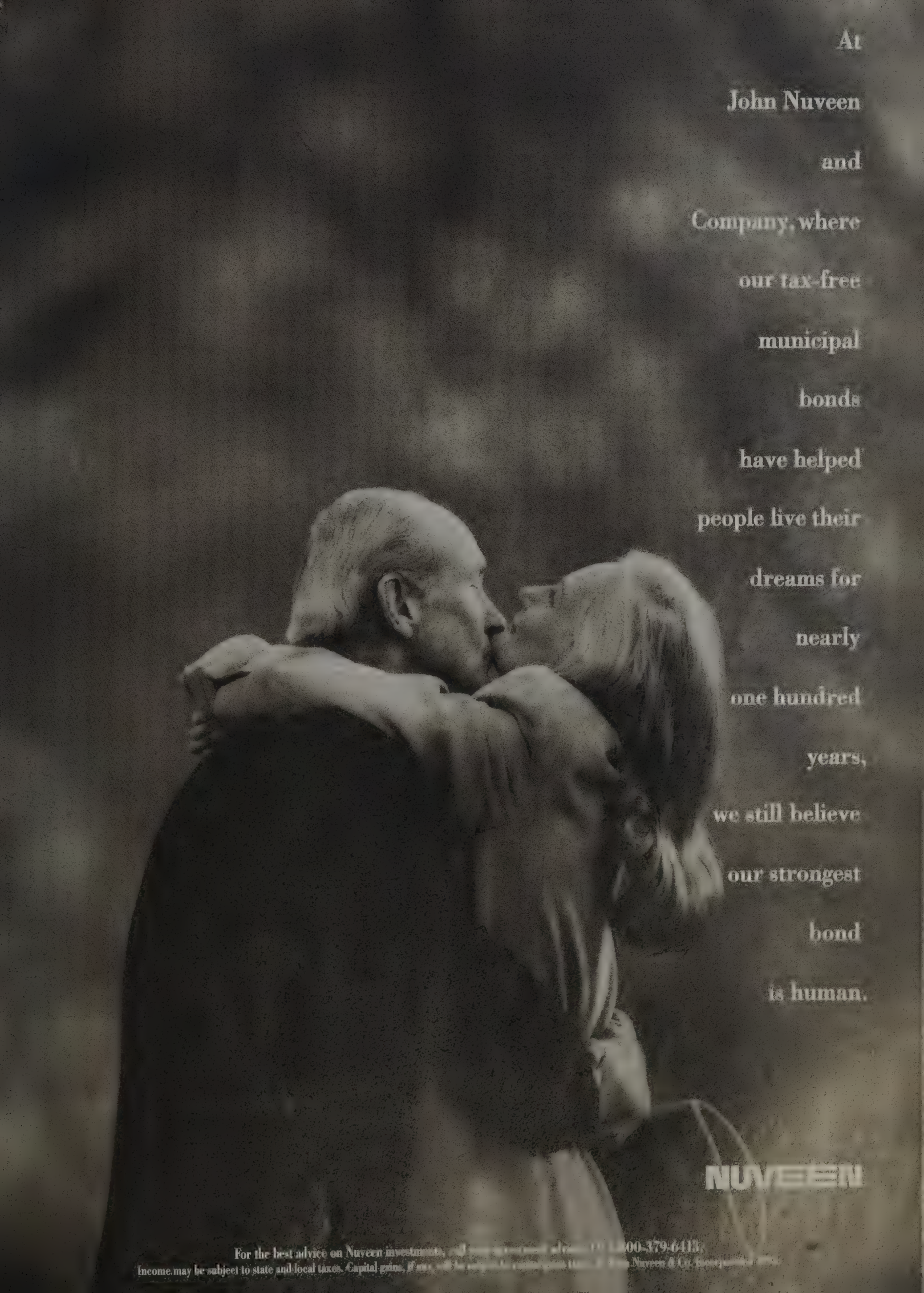
Our discovery that cicadas can sweat fills out a remarkably symmetrical array of evaporative cooling mechanisms in insects and vertebrates. In both groups, movement of air over moist respiratory surfaces is one frequently used method, exemplified by panting in dogs and grasshoppers. Evaporation from mouthparts is also widely used in birds and reptiles (gaping in crocodiles, for example), and honey bees reduce the temperature of their head by extruding a droplet of fluid into their mouthparts and reingesting it after it has cooled. When faced with extreme thermal stress, kangaroos lick their fur, and many species, such as tortoises, vultures, storks, goats, and camels, urinate on their legs. The resultant evaporation can provide life-saving, albeit short-term, cooling in thermal emergencies. Among insects, Australian sawfly larvae smear rectal fluid over the surface of their body and the bodies of nearby kin, allowing them to survive air temperatures as high as 115° F for more than an hour. With the documentation of sweating in cicadas, we now know that insects have independently evolved the complete repertoire of evaporative cooling mechanisms used by vertebrates. □

A photomicrograph reveals clusters of sweat pores in the cicada's cuticle.
Eric C. Toolson






He
can go hours at
a time
without saying a
word. And yet,
she still
knows exactly what
he's thinking.
It's something you
have to experience to
truly understand.
If you have,
no explanation is
necessary.
If you haven't,
no explanation is
possible.
The human bond"


At
John Nuveen
and
Company, where
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municipal
bonds
have helped
people live their
dreams for
nearly
one hundred
years,
we still believe
our strongest
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A Wasp Keeps Its Zombielike Victims Cool

by David Ward and Joh R. Henschel

After leaving Egypt, Moses and the people of Israel spent forty years wandering in the barren Wilderness of Zin. Today, the wilderness is still a forbidding place, not only for the people that inhabit it but also for its wildlife. Located in the central Negev highlands of Israel, the Wilderness of Zin is a large plain surrounded by limestone hillsides, with a sparse scattering of shrubby vegetation. Resources are scarce, rain rare, and the heat overwhelming, especially in the summer when temperatures get as high as 110° F.

One animal that has adapted to the harsh environment is *Stegodyphus lineatus,* a three-eighth-inch-long, virtually unknown desert spider with no common name, which builds its nest in the tops of dwarf shrubs scattered over the limestone hillsides. Mostly white, with black stripes on its abdomen, this spider shields itself from the direct sun by building a tubular nest of dense, "woolly" silk, with the entrance usually facing the ground. Flying insects are captured in an "untidy," orblike web that radiates from the mouth of the nest.

Some aspects of the nest design actually make the spider's environment even hotter. By reinforcing the nest walls with leftover bits of prey and plant debris, the spider protects its home from strikes by birds, but it also cuts off circulating air. How do the spider withstand the heat?

A desert spider escapes to its densely woven nest to avoid direct sunlight, but must emerge again if nest temperatures rise too high.
David Ward



In the desert, a wind usually comes up in the afternoon as h air rises from the land and meets with cooler air higher up. this time of day, we have seen spiders cooling themselves hanging out of their nest entrances and exposing their large a domens to the wind. But these spiders are not the only ones l ing in these nests and thus not the only ones that need a cooli strategy.

One of the spider's major predators is the tiny parasitoid wa *Pseudopompilus humboldti,* which lives by paralyzing and co suming a living host. The female *P. humboldti* spends her ad life searching for a spider host on which to raise her young. Fl ing onto a capture web near the attachment to the nest, the wa vibrates her wings. This movement simulates the vibrations o captured flying insect and stimulates the spider, which has be hiding inside the nest, to move toward the entrance. Rushing in the nest, the wasp stings and paralyzes the spider, and then la her egg on its abdomen. When the egg hatches after about sev days, the larva consumes its anesthetized but still living host f the two weeks it takes to develop into a free-flying adult.

Suitable hosts for parasitoid wasps are few and far betwee however. In some species, more than one wasp may lay its eg on a single host, or one parasitoid wasp may lay an egg on a other's larva. To avoid such outcomes, many parasitoid wasps g to great lengths to hide the host. Temperate-zone wasps, for i stance, often store their prey in a cool, underground cell made mud. This option is not available to desert wasps owing to shortage of water for making the mud cell. So the desert was after laying her egg on a spider, pushes the paralyzed but still li ing spider host to the exposed nest entrance. Why does she ri placing her eggs where they are so susceptible to predators an so visible to other female wasps? Since a dead spider w quickly dry up and lose its nutritive value, we hypothesized th the wasps pushed their prey to the nest entrance because that w the only place where the spider would not fatally overheat.

To test this hypothesis, we performed a simple experimen We placed six parasitized spiders deep within their nests. To cr ate a control, we moved another six parasitized spiders abo within their nests before returning them to their original pos tions at the nest entrances. This manipulation of the contr group insured that any difference between the experimental an control animals was due to the change of position in the nest an not to our disturbance alone.

At the same time, we measured temperature outside and i side the nest with a temperature probe, or thermocouple. An other thermocouple was threaded through a fine syringe needl into the abdomen of a live parasitoid larva attached to the ab domen of a paralyzed spider. Throughout the day, the body tem perature of the wasp larva at the nest entrance was cooler tha the air within the nest. At the highest air temperatures recorde between midday and 3:00 P.M., the larva at the nest entrance wa almost fifty-nine degrees cooler than the temperature dee within the nest, which reached more than 120° F.

One week after the manipulation, all six experimental spide that had been placed inside the nests had dried up and died. Fou of the six control spiders at the nest entrances survived until th wasp larvae pupated; the remaining two fell prey to birds an ants. Although the scientific literature is replete with examples o behavioral thermoregulation in arthropods, this case is unusua There is, to our knowledge, no previous record of one species ac tively regulating the body temperature of another. □

Ants That Are Not Too Hot To Trot

by Alan C. Marsh

On my first field trip to southwestern Africa in 1981, I remember eating my lunch in the shade of a tree to escape the noon . I noticed medium-sized, long-legged black ants rushing about collecting cheese crumbs at my feet and then, to my astonishment, streaking out of the shade and across the hot sand. The sand was a scorching 150° F! Periodically an ant would climb up a short piece of grass stubble, pause for a few seconds, and then resume its race across the sand. My curiosity was aroused: How did this insect, the Namib ant *Ocymyrmex robustior,* function in such intense heat?

Heat

For Namib ants, a typical day in the desert begins, not at a standard time, but at a standard sand surface temperature, 86° F, at which point the first individuals emerge from their subter-

A Namib ant takes a breather on a dry stem before racing across the scorching sands.
Alan C. Marsh



ranean nest and stagger off in search of food. They stagger because their bodies are too cold for coordinated movement; but as the day grows hotter, more ants emerge, setting off in a more coordinated manner and at progressively faster speeds. Traffic in and out of the nest peaks at 126° F, trailing off if the temperature rises above this point and ceasing altogether at 154° F, a high point usually reached an hour or so before midday. Later in the afternoon, as temperatures begin to drop, a few ants rush out of the nest and are soon followed by others as foraging recommences and continues until the surface temperature falls to 86° F. Thus, each day has two activity peaks, with the afternoon being the busier time.

Individual ants often travel nearly 200 feet from the nest in search of food—usually dead insects that have succumbed to the heat. By foraging during the heat of the day, these ants do not have to compete for food with other ant species. This lack of competition explains why ants forage when they do, but how do they endure the heat?

Ants can tolerate a constant body temperature of 125° F and can briefly withstand even higher air temperatures if they can take breaks in cooler air. This is where grass climbing comes in. Air temperatures fall rapidly with slight increases in elevation above the sand. For example, when sand temperature is 154° F, the air at ant height is 131° F. The long legs of the ants are an adaptation to heat, and they also facilitate rapid locomotion.

When sand surface temperatures are more than 126° F, the ants climb plant stems and other objects and pause to cool down. The ant's small body quickly cools to the level of its surroundings. Ambient temperatures at stem height typically range from 86° F to 101° F. These cooling periods enable the ant to forage intermittently in intense heat.

At high temperatures, an ant will succumb to heat death if it fails to locate a cool site within seconds. I saw this happen on several occasions. The ants risk death every time they venture out of the nest at sand temperatures greater than 126° F.

Making a living as a heat-loving ant, however, involves more than just finding heat-stressed insects and avoiding becoming one oneself. Another hazard lurking in the hot sand is the voracious ant lion in its larval stage. Ant lions bury themselves at the base of steep-sided conical pits; their only visible parts are the long, curved jaws that lie agape awaiting the arrival of prey—a wait that may last several days. When some hapless creature does fall into the pit, the ant lion springs into action, flicking sand at its potential victim to start an avalanche that brings the prey within striking distance. The ant lion then snaps its jaws shut, injecting poison and digestive juices into its victim. Sucking out the prey's body juices, the ant lion dines at its leisure. Finally, with a flick of its head, it flings the carcass out of the pit.

Ant lions will eat any arthropods that enter their pits. However, for this sit-and-wait predator, the best meal around in terms of abundance and size is the Namib ant. Consequently, a meal is most likely to fall into the ant lion's pit when temperatures are extremely high. But ant lions can remain in their pits only until the temperature in the pit base reaches about 127° F. If it gets any hotter, they will become temporarily paralyzed, and any further temperature increases may kill them. Therefore, when in danger of heat death, ant lions burrow to cooler depths, up to eight inches beneath their pits. Although both Namib ants and ant lions would be safer below the surface when it becomes hot, neither would be able to feed there. It pays for them to push their physiological limits, cooling off only when the risk of death is imminent. □

Beetles Make Their Own Waxy Sunblock

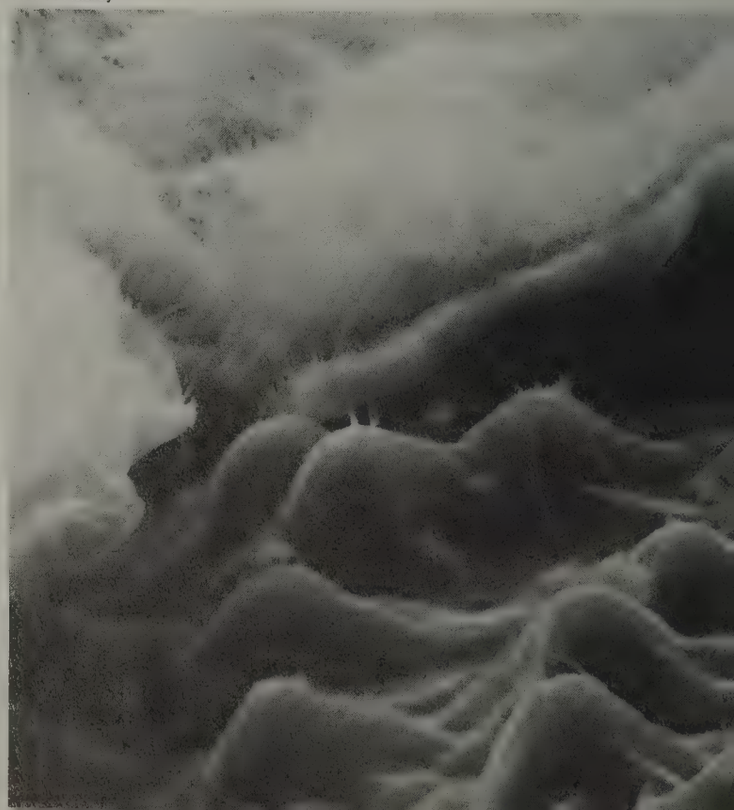
by Neil F. Hadley

Exposed to cool, humid conditions, a desert-dwelling darkli beetle may appear jet black. But placed in hotter, drier surroun ings for a even a few hours, it becomes transformed into a po dery white beetle, which at first glance looks like an entirely d ferent species.

Darkling beetles accomplish this remarkable change by exu ing waxes from thousands of tiny pores on their cuticle, or ou covering. Such wax "blooms" appear in a variety of other i sects, including moths, butterflies, bees, aphids, and true bu The waxes can be manufactured by special cells in the insec epidermis or they can be obtained directly from the insect's di They serve a variety of purposes, from defensive barriers that e tangle potential predators to chemical signals to other insec Wax blooms are prevalent in desert species, particularly amo darkling beetles in the family Tenebrionidae. In the Nam Desert of southwestern Africa, twenty-six species of darkli beetles have wax blooms, each with a characteristic color a pattern covering either part or all of its cuticle. As in other i sects, the waxes in a darkling beetle's cuticle provide a critic barrier to water, preventing dehydration, but additional, excret wax provides an extra barrier against the desert sun.

A scanning electron microscope image of the surface of a Sonoran Desert darkling beetle shows its cooling layer of wax partly removed. The wax filaments are extruded from thousands of pores on the cuticle.

Neil F. Hadley



With the aid of the scanning electron microscope, I have studthe fine structure and arrangement of these wax deposits. In *ptoglossa verrucosa,* a Sonoran Desert species of darkling tle, gland ducts open at the tip of small, knoblike projections t are spaced at regular intervals on the cuticle surface. As the x is secreted, it is an amorphous blob, similar to toothpaste ng squeezed from a tube. But if the humidity is low, the wax lecules organize into numerous slender filaments that radiate m the knobs. These eventually spread and connect with filants extruded from other ducts to form a basketlike mesh covng the entire surface of the beetle. The wax meshwork scatters ht, producing the bluish white color that these beetles take on en kept under warm, dry conditions. In other species, the wax ting takes other forms, depending on the shape of the pore enings, the chemistry of the wax, and environmental condins. These randomly oriented granules, rods, filaments, and pons give the insects a powdered appearance. In some spes, this wax bloom is so dense it often completely obscures the derlying cuticle.

Heat

The lighter coloring produced by the wax blooms reflects much more sunlight than the beetle's black cuticle, which would absorb the sun's rays and heat up quickly. Elizabeth McClain, a desert biologist at the University of Namibia, has measured the cooling effects of white wax blooms on *Cauricara phalangium,* a Namib Desert darkling beetle. She found that the amount of light reflected from the white portion is several hundred times greater than from the wax-free, black areas of the cuticle. Similar results have been obtained in the laboratory with other darkling beetles. In addition to helping the beetles conserve water, the lower cuticle temperature also helps to keep the insects' body temperatures from rising too high, permitting the beetles to forage on the hot surfaces for long periods. □

A darkling beetle performs a handstand to raise its body above the Namib Desert's sands. The yellow wax on its cuticle reflects sunlight, instead of absorbing it as the dark, waxless areas do.
Michael and Patricia Fogden







Head Start For Terns in the Shade of an Alien Pine

by Russell E. Shea

The Battle of Midway marked the turning point of World War II in the Pacific, bringing worldwide fame to this remote subtropical atoll. Decades before that, Midway was used by the Pacific Cable Company as part of its cable-laying operations and, later, by Pan American Airlines as a refueling stop for the old Clipper ships. Human activity is much reduced now, but the atoll is still very much alive and provides breeding grounds for more than a million seabirds, belonging to fourteen different species.

At least nine of these species nest in the open, exposing eggs, chicks, and adults to intense sun. The sooty tern, which commonly lays its single egg in a shallow depression dug from coral rubble and which has black, heat-absorbing feathers on its back, is perhaps the most exposed of all. During the breeding season, air temperature at nest level often exceeds 100° F and ground temperature may rise above 122° F. To make matters worse, the light-colored, highly reflective coral rubble is a source of additional heat. Since unattended eggs may quickly reach lethal temperatures of 108° F (average egg temperature during incubation is 101° F), adults spend much of the twenty-six-day incubation period cooling, rather than warming, their eggs. During the hottest part of the day, for example, parent birds spend more than 90 percent of their time shading their egg. Adults also make frequent trips to the water's edge to wet their breast feathers. The water soaked up this way can be used to cool the egg by evaporation, as is done by Egyptian plovers, killdeer, and a number of other shorebirds.

After hatching, sooty tern chicks grow slowly, fledging after fifty-five to sixty days of complete dependence on their parents for food (mainly flying fish and squid) and water (which is regurgitated along with the food). Young chicks also rely completely on shadows cast by the parents' bodies for protection from the heat. If left in the open, a two-day-old chick (weighing roughly one ounce) may reach a body temperature of 112° F in fifteen minutes. At this temperature, the central nervous system malfunctions. Unable to stand, orient itself, or move to shade, the chick soon dies. Older chicks (fourteen days and older) are no longer sheltered by adults and may reach similar temperatures but can cool themselves down effectively by panting and seeking shade. Panting (which facilitates the evaporation of water from the respiratory lining) cools the bird, but it also uses up precious water. Without access to shade, the chick can regulate its temperature only if it gets enough water.

Nesting sooty terns seek the shade of casuarina trees, introduced on Midway Island earlier this century.
Russell E. Shea

Heat

Gathering food for themselves and their offspring is not an easy task for seabirds nesting on Midway. Sooty terns and most other true oceanic birds may fly tens of miles offshore to feed (generally ignoring, for unknown reasons, the richer water immediately surrounding the atoll). They bring back meals at least once a day, most frequently in the late afternoon or early evening; about half the time, the chicks will receive two food deliveries a day. Sooty tern chicks under four weeks old have enough fat to survive about five days without food, but they rarely last that long, suggesting that, for the short-term anyway, the lack of water is of greater consequence.

What physiological and ecological adjustments must birds make to breed in such a harsh environment? Fortunately, Midway provides a natural experiment allowing us to find some answers. During the early part of this century, both the Pacific Cable Company and Pan American Airlines brought in nonnative vegetation to the island, including a tree in the genus *Casuarina,* commonly known as the Australian pine. Casuarinas have spread over much of Midway, many of the trees growing up through cracks in the abandoned runways. The trees provide shade and, through evapotranspiration, natural air conditioning. Air and ground temperatures under the casuarinas rarely exceed 84° F and 90° F, respectively.

Sooty terns generally establish breeding colonies under the trees first, occupying areas in the open only after the shaded spots are all taken. Adults that nest under the trees rarely shade eggs or chicks, and both adults and chicks are only rarely observed panting, a common sign of overheating.

Comparing chick growth in the two habitats, we found that through forty days of age, those chicks lucky enough to be in the shade of a pine tree grew about 15 percent faster than those in the open, with no discernible difference in food intake. Also, although our field experiments detected no difference in daily energy expenditure between birds in the two types of habitat, water loss was substantially greater in chicks raised in the open. These data suggest that shaded chicks use less energy maintaining normal body function and can thus allocate more to growth.

Sooty terns adapted long ago to Midway's harsh environment, nesting successfully for countless years before there was a single pine to offer shade. However, able to recognize a good thing when they see it, at least some of the birds can now provide their chicks with the very tangible benefits of keeping cool.

A sooty tern chick pants in the heat.
Frans Lanting; Minden Pictures



Penguins with a Latitude Problem

by Lloyd Spencer Davis

Windborne snow stings the few exposed parts of my face. I am wearing woolen long johns, a woolen shirt, over-trousers made from a metallic space-age material, a dacron vest, and a jacket—a huge jacket—filled with goose down. My thick-soled mukluks would not look out of place on the moon, and my polypropylene gloves are covered by mittens made from the reversed hide of some furry animal long dead. A woolen balaclava, polarized ski goggles, and wolverine-fur-trimmed hood complete my ensemble. And despite the combined warmth of the best natural and high-tech fibers available, I am cold. I've been sitting still for about three hours, and the antarctic wind, the snow, and even the view of the icebergs has chilled me to the bone. During that time, the Adélie penguins I have been watching have hardly moved. Apparently untroubled by the bitter cold, they lie snug on their nests of stones, incubating eggs, standing occasionally to shake the snow crystals from their backs before resuming their vigil.

Penguins are usually portrayed as I see them now, against an inhospitable landscape of ice and snow. So when I speak of penguins and thermoregulation in the same frosted breath, one might suppose that penguins need mainly to find ways to keep warm. That, however, is far from the case; when on land, the problem most penguins face is how to keep cool.

This predicament stems from their life in the sea. Penguins are flightless, aquatic creatures, and water has about twenty-five times the thermal conductance of air. To survive for long periods in water, warmblooded animals must have insulation. Whales have blubber to buffer their body heat against the waters that would draw it away. Seals have thick pelts, as well as fat. But birds have no fur and, because their ancestors dispensed with any feature that would encumber becoming airborne, they have only a limited amount of body fat. Their covering of short, stiff

A yellow-eyed penguin returns from a fishing trip. To dissipate excess heat generated by swimming, blood vessels in its feet and flippers dilate, turning the unfeathered areas bright pink.
Jean-Paul Ferrero; AUSCAPE International





Magellanic penguins in the Falkland Islands stand in pairs at the entrances of their nesting burrows. In warmer parts of the species' range, the burrows provide shelter from the heat.
Tui De Roy; The Roving Tortoise

feathers interlock to trap air, forming the ornithological equivalent of a diver's suit. This insulation also allows some penguin species to happily make landfall in high latitudes where most other birds fear to tread. The same feathers that keep heat in also keep it from getting out. Thus, penguins ashore risk overheating, especially penguins of temperate and tropical zones.

For temperate zone penguins, such as the yellow-eyed penguins that breed on New Zealand's South Island, walking around in a feather wet suit when temperatures approach 85° F can be downright uncomfortable, and in the case of their chicks, life threatening. My student Phil Seddon and I found that the species avoids direct sunlight by choosing a sheltered place to nest in the coastal forest. Plants one to three feet overhead are the most important feature of the ground nest site. Birds with shaded nests rarely display signs of heat stress, while those whose nests are less than 50 percent shaded spend more time standing up and panting.

Penguins breeding even nearer to the tropics seek shelter from the sun by nesting in burrows and caves. Some, like the little blue penguin, which breeds on the coasts of New Zealand and Australia, go one step further, usually coming ashore only after sundown. Humboldt penguins, found on the coasts of Peru and Chile, dig burrows in their own guano (an example of food being eventually recycled as shelter). A close relative breeding at the equator, the Galápagos penguin avoids the sun by nesting in cracks in the lava rocks of the volcanic islands.

Even at the equator, where the water temperature reach 80° F, the sea still acts as a huge heat sink for birds that mu keep their internal temperature at about 102° F to survive. even tropical penguins must maintain the integrity of their feat ered shield. This armor limits the penguins' potential for physi logical management of heat stress. Preventing overheating is t best tactic, but the shade of bushes and burrows can do only much. Penguins also need "windows" that allow superfluo body heat to escape.

Humboldt and Galápagos penguins and their relatives do ha patches of unfeathered flesh on their face. But the chief heat r diators of penguins are their flippers and bare feet. The feathe on the flippers of all penguins are extremely short and provide, best, only modest insulation. By controlling the position of t flippers and feet, and the blood flow to them, the birds can mi mize or maximize heat loss. Hot penguins, for example yello eyed penguins with poorly shaded nests, hold their flippers out an angle of about 45° to the body. The blood vessels in the fe and underside of the flippers dilate, turning those areas pin This is easiest to see in a bird that has just come ashore and nee to rid itself of the heat generated by swimming. When the bir are even hotter, they pant. Hyperventilating evaporates boo water, using up body heat in the process. My Adélie penguir and Phil Seddon's yellow-eyed penguins pant mostly just aft midday, when temperatures are highest.

Chicks also face the danger of overheating because on cal days their down is even more efficient than the feathers of adul at retaining heat. Penguins that breed in the open often shad their young chicks by standing over them. As the chicks g older, they are able to regulate their own temperatures, and the may move away from the protection provided by their parent

e down-covered flippers of chicks hold in more heat than the
pers of adults, so chicks rely more on their disproportionately
ge feet to act as radiators. On hot days, they lie spread-eagled,
ir flippers at their sides and their feet exposed. Yellow-eyed
nguin chicks may even seek out marshy ground and stand with
ir feet in water.

Water is the true element of penguins. They come onto land
y to breed and molt. The risk of hyperthermia from insolation
en they are on land is the price they pay for the insulation they
d at sea. Ultimately, if the heat becomes unbearable, they can
back to the sea. At the equator, Galápagos penguins have
n observed to abandon their nests and retreat to the ocean,
ving their eggs or chicks to fry in the sun. The nesting Adélies
ave been observing should not have to resort to such extreme
asures. And as I pull my hood even tighter to ward off the
d, a cool dip is the last thing I want to contemplate. □

A Mussel Wears an Expensive Seaweed Scarf

by Deborah M. Brosnan

Hike across any exposed rocky shore in the temperate regions
the world and you'll notice mussels covering much of the in-
idal zone. (You'll probably be walking on them.) These
ck-shelled mollusks, which anchor themselves to rocks by
ng threadlike secretions, are gregarious. Thousands settle
e by side in colonies. More than 300 other kinds of animals
l plants live tucked in the recesses of mussel beds, where they
protected from predators and environmental extremes. Other
anisms, notably seaweeds, barnacles, and limpets, take up
idence directly on mussel shells.

In late 1989, I was studying mollusks along the Oregon coast,
en a fierce December storm covered rocky shores and
aches from Washington to northern California with snow.
mperatures plunged to 10° F. Two weeks later, I walked the
re amid the smell of rotting shellfish. Most of the California
ssels, *Mytilus californianus*—which average about three
hes long and are found from Alaska to Mexico—were dead.
ly those that had seaweed, a red alga known as *Endocladia*
ricata, on their shells survived. I examined more than 6,000
ssels on over 200 miles of coastline, and on every shore, the
tern was the same. A series of experiments in both the field
l laboratory confirmed that *Endocladia* provided insulation
t protected the mussels from freezing.

I wondered if this insulation could also be important in warm
ather. Along the coast of Oregon and California, when sum-
r low tides often occur during the late morning and early af-
noon, mussels are exposed to the full heat of the day. During
summer, my colleagues and I used an infrared thermometer
measure shell and internal temperatures of mussels on rocky

Heat

shores. On hot days, mussels with *Endocladia* were significantly cooler than those without, often by as much as nine degrees. This temperature difference can mean life or death to a mussel. Above about 70° F, California mussels suffer heat stress, and if a warm spell continues for a few days, they begin to perish. A cap of seaweed provides shade and probably helps the mussel retain moisture.

We found that *Endocladia* does not settle directly onto mussel shells, but onto barnacles—stationary, shelled arthropods—that are already adhering to the mussels. The alga then proceeds to overgrow and to smother the barnacle "middlemen." Another player in this web of associations is the limpet, a marine snail. Because limpets are grazers and cruise over the surface of a mussel shell feeding on young algal plants, we thought that perhaps limpets grazed on any *Endocladia* that settled on mussels. But contrary to our expectations, we found that not only do limpets refrain from eating *Endocladia,* they actually appear to enhance its effects.

If *Endocladia* protects mussels from heat and cold, then why aren't all mussels clad in seaweed? The answer is probably that this protection comes at a price. Because mussels live for fifteen to twenty years, they are apt to be subjected to many hot and cold spells over time. But mussels mantled with algae have about twice the drag of mussels without it and are ripped more often from their rocks by waves, particularly during storms. A mussel can strengthen its holdfast by secreting extra threads, but this costs energy that it could otherwise devote to growth and reproduction. On some beaches, 79 percent of California mussels had algae; on others, about 40 percent. Overall, about half of these mussels on the northwest Pacific coast appear to have made the trade-off between insulation and stability and readily accept a contingent of hangers-on—barnacles, limpets, and seaweed.

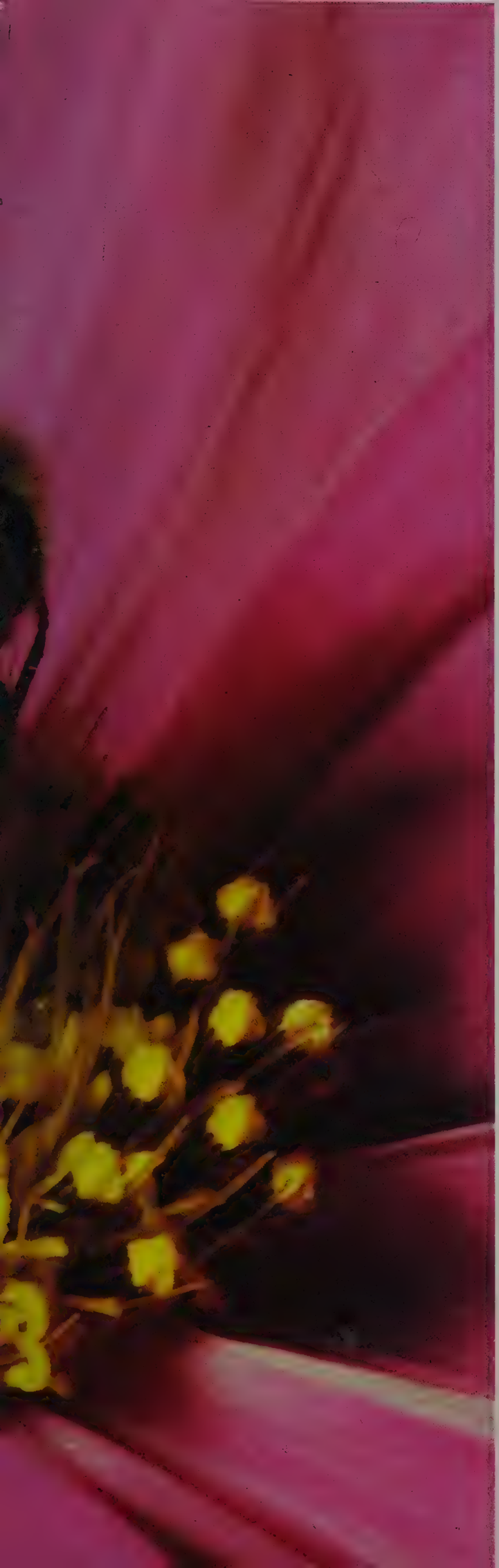
Unlike the California mussel, the blue mussel, *Mytilus edulis,* can withstand a relatively wide spectrum of temperature. Its range also includes the Pacific coast of North America, but it tends to occupy higher, narrow bands of beach, where it is exposed to greater extremes of heat and cold than is the California mussel. Having evolved under these conditions, the blue mussel has little need for extra protection and keeps its shell free of seaweed and barnacles by regularly sweeping its foot across its shell to remove freeloaders. □

Low tide reveals a starfish on a bed of California mussels mantled in seaweed.
Deborah M. Brosnan



Heat





Comfort in a Hive: Heads You're Hot, Tails You're Cold

by Bernd Heinrich

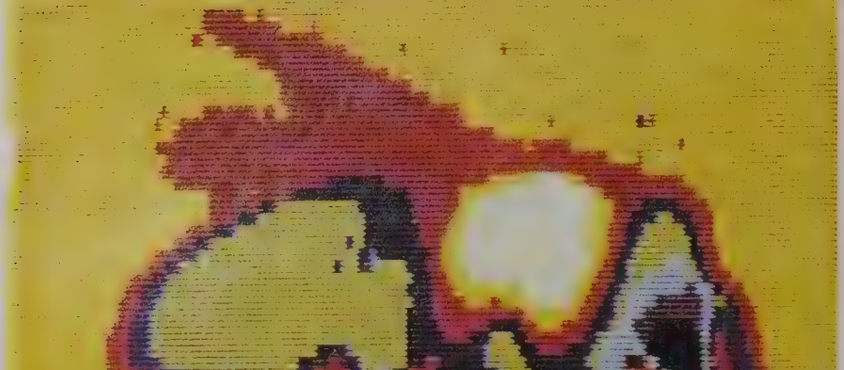
A female honey bee worker flying on a hot day has to contend not only with the sun's withering heat but also with her own internal furnace. To drive her wings, the honey bee contracts the powerful flight muscles in her thorax some 200 times per second, a process that produces a tremendous amount of heat. The honey bee's internal temperature would reach lethal levels (118°–122°F) and the insect would "fry" internally in a minute or two of flight if not for her small size and for the air flow she generates during flight, which allows heat to escape by convection.

Landing on a clover blossom to forage on a windless day, however, the honey bee faces the full brunt of the sun's burning rays. Although she has stopped flying, her temperature could still become dangerously high. Having filled her honeycrop with nectar and loaded her pollen baskets, the honey bee worker flies straight back to her colony, which is packed with the pressing bodies of tens of thousands of equally hot hivemates. Nonetheless, thanks to a few adaptations in their physiology and behavior, honey bees survive and prosper even in hot deserts.

Much has been made of the advantages of bees' staying hot. For example, flight muscles need to be hot enough to contract rapidly during flight, and the nest has to be warm enough to incubate the young so that they can grow quickly. But being able to cool down also has its advantages. In the immediate sense, it can keep the bees from frying; in the long term, it can also save energy. The biochemical motor that drives the bees' wings cannot be totally shut off, and its idling speed doubles with every 18° F increase in temperature. Therefore, prolonged high temperatures can cause the bees' quickened metabolisms to burn considerably more energy.

Most large flying insects have evolved a mechanism to prevent overheating during flight; blood circulating through the flight motor carries heat from the thorax to the abdomen, which gets rid of the heat, much as the coolant circulating through an automobile engine passes through the radiator. The honey bee's peculiar anatomy, however, makes this impossible. The tube that carries the blood from the abdomen into the thorax is thrown into tight coils in the petiole area, the narrow passage that links the two sections of the body. This means that hot blood leaving the thorax must flow around these coils, heating the cool blood being pumped into the thorax—and very little heat escapes into the abdomen. This inability to use their abdomen as a heat radiator may appear to be a handicap, but it probably serves the honey bees well when they are flying in cool weather. Relying on convection to unload excess heat has its limitations, however; it only works if the body is hotter than the surrounding air. A radiator

A honey bee may deliver dilute or concentrated nectar, depending on the temperature in the hive.
Bernd Heinrich



In this thermogram of a honey bee that has just returned to the hive, the thorax (which contains the flight muscles) is white, corresponding to a temperature of 105° F. The surrounding air is a cooler 90° F.
A. Stabentheiner and S. Schmaranzer

may increases the area for convective cooling, but it relies on convection nevertheless.

Honey bees have evolved a totally different cooling system that may be the most efficient of any insect, one that has allowed them to abandon the abdominal heat radiator altogether. When a foraging honey bee flies at high air temperatures and passive convection no longer suffices to keep her head temperature below 113° F, a thermal sensor there triggers the response to regurgitate nectar from her honeycrop onto her tongue. Exposed to the air, water from nectar evaporates, cooling the bee's head, and drawing heat away from the adjacent thorax. She can increase the rate of evaporation by "wagging" her tongue and by smearing some of the liquid on the front of her thorax. Evaporative cooling is the only way the bee can lower her temperature below that of the ambient air. A further advantage of relying on evaporation is that while the forager is cooling herself, she is simultaneously reducing the load of excess water she is carrying and saving energy. By carrying less water, the forager also has extra space to transport more calories to the hive.

On returning, the forager may still be hot, but now she is subjected to the metabolic heat of thousands of her hivemates. The bee quickly passes her nectar to one of the receiver bees that stay within the hive; she then leaves for another trip. If it's hot, these receivers eagerly take up the nectar and cool themselves and the hive by regurgitating it so that it evaporates from their own mouthparts, as well as from droplets they deposit in the honeycombs. As a result, the humidity of the hive shoots up, which stimulates some of the workers to fan the entrances to the hive. This brings in drier air, making more evaporation possible. If, on the other hand, the weather is cool, few receiver bees will be willing to unload foragers bringing in dilute nectar. Instead, the receiver bees now only accept foragers bringing in concentrated forage. Thus, receiver bees can manipulate the foragers to bring in dilute or concentrated nectar, depending on the temperature.

Bees in the core of the hive can also become dangerously overheated in the winter. The outermost bees may be cool, some even approaching their minimum tolerable temperature of 59° F, but as the air temperature outside drops, the temperature at the center of the cluster rises. For many years, researchers assumed that the bees on the outside had some way of communicating

Hea

with the bees in the core who could, by regulating their own heat output, produce more or less heat as needed. But experiments failed to show any such communication. Further studies revealed that t core bees' high temperatures resulted from their resting metab lism alone. And because their resting metabolism increases their body temperature rises, the core bees produce more heat they heat up. But why did the core bees get hotter as outside ter peratures were lowered?

The answer lies with the mantle, or outer, bees. They are t ones who control core temperature. When honey bees are in cluster, they allow their body temperature to "float" passive over a wide range, whereas solitary individuals shiver to mai tain a thoracic temperature of about 92° F at all times, presur ably to be instantly ready for flight. As their temperature d clines, the mantle bees' first line of defense is not shiverin Instead, they merely crawl into the inside of the swarm cluste Increased huddling shrinks the cluster, and air passages to t outside become plugged. Eventually, the outside bees a jammed so closely together that their heads point in and their a domens stick out. Heat loss of the cluster is then at a minimur and if the swarm is a large one, the core temperature may sho up to within several degrees of lethal temperatures.

For every action there is a reaction, and the overheated co bees are not passive. They crawl toward the cooler peripher thus creating holes that let out heat, warming the exterior be and causing them to crowd less tightly. Normally, both respons occur simultaneously in any one swarm in a dynamic proces and one only sees the net effect as the bees continually shift the position within the hive. Only when the swarm is subjected sudden temperature changes are the separate actions noticeabl If a swarm is suddenly taken from room temperature to su freezing temperature, the outside bees feel the temperatu change first. They immediately clump, and swarm core tempe ature shoots up before core bees get a chance to respond. Co versely, when the swarm is suddenly taken from subzero ten perature to room temperature, the outside bees loosen the cluster, and core temperature plummets.

The power of the mantle bees to affect core temperature well illustrated by the defensive reaction of the Asian honey be to predatory hornets. In Japan, the honey bee *Apis cerana* co fronts a species of large, heavily armored hornets, *Vespa simi lima*, that prey on them. These hornets often patrol in front of a entrance to a weak hive and snatch one bee after another, some times depopulating whole hives. The hornets are heavily arme against bee stings, but they are not immune to the lethal effec of overheating, which the honey bees have exploited as a de fense. At strong hives, the hornets may first be grabbed and hel by several bee defenders, and then 200 to 300 bees will cluste tightly around the attacker. These defensive bees are already ho ter than those just flying off to forage, and as they form a ba around the hornet they continue to shiver. Temperatures at th core of these small clusters, where the unfortunate hornet is hel fast, soar to 115° F. Because the hornets' lethal temperature slighlty lower than the honey bees' (113°–116° F versu 118°–122° F), the victim at the center of the bee ball dies. □

Honey bees huddle to warm themselves, a behavior that rapidl overheats the core of the hive, forcing interior bees to cool themselves by moving to the periphery.
Mitsuhiko Imamori: Nature Production



Ancient Indians Sought Shadows and Ice Caves

by Daniel J. Lenihan and James E. Bradford

Shoveling dirt on a bright summer day in Canyon de Chelly, a deep ravine carved into the western slope of the Chuska Mountains of northern Arizona, archeological field crews cast longing glances at the approaching shadows. The prehistoric inhabitants who lived here also paid attention to solar orientation. On the arid Colorado Plateau, despite an average elevation of 5,000 feet, temperatures often exceed 100° F during the summer. In lower, moister locales, a thicker atmosphere tends to steam-cook a person more evenly, but in the Southwest the sun really counts.

The Anasazi ("ancient ones," in the Navajo language), fi occupied Canyon de Chelly more than 2,000 years ago. The e liest Anasazi, known to archeologists as the Basket Makers, to advantage of subtle alignments of the landscape for protecti from the sun at critical times of the year. Realizing that a narr ledge in the canyon wall faced north, they would dedicate the e tire site to the construction of storage units, digging small pits the dirt and debris fallen from the overhanging roof of the roc shelter. They lined the pits with sandstone slabs bonded by m mortar and roofed them with beehive constructions of sticks a mud. This enabled the Basket Makers to store food (corn, bea pine nuts, squash) for a long time in a cool, dry environment the middle of a sandstone hotbox.

In the winter months, the canyon rims and flat country outsi the canyon entrance provided prehistoric inhabitants with ea exposure to the sun's warming rays, while the cooling shade the canyon bottoms afforded refuge in the heat of summer. T later Anasazi, or Puebloans, constructed elaborate buildings stone and mud mortar, which they nestled in shady canyon coves. To this day, the resident Navajo live on the canyon botto in the summer and the rim in the winter.

Another basic strategy of Native Americans in the Southwe was to burrow into the earth, roofing semisubterranean hom



Heat

earth-covered wooden frameworks or digging underground llings. In the earliest recorded description of a Navajo lling, dating to 1630, Fray Alonso de Benavides mentions a *enda debaxo de tierra,* "a dwelling under the ground" or elling under earth." He probably was referring to an ancesversion of the hogan, perhaps a hole with hide stretched over top. The typical hogan of today is constructed from logs, , earth, and stone and possesses a sunken floor that provides ooler environment. Some hogans have root cellars, rooms still deeper floors insulated with additional dirt and logs. ir inside temperatures are significantly cooler for storage of shable foods.

Caves, a source of protection from many types of meteorolog- mayhem, are also excellent insulators against heat. Lime- e caves provide natural air conditioning, maintaining a ly constant temperature year-round. The contrast is even e dramatic when the cave lies in dark rock, such as basalt, or lened lava, whose surface absorbs much radiant heat.

Near Acoma, a still-occupied pueblo in western New Mexico, El Malpais—the badlands. The meager tree cover to be id, consisting of low-lying junipers, piñon pines, and ponosas, affords little refuge from the black, jagged basaltic blan- Not far below ground, however, are natural cavities that are oases of coolness. Lava tubes that hardened around molten rivers of rock provide makeshift thoroughfares to these sanctums, into which the dense, cold air of winter settles and remains. Ice forms in them as well, and depending on a cave's size and shape and the location of its entrance hole, it may be preserved throughout the year. Ice cave temperatures hover around freezing throughout the summer, in some cases maintaining ice that is 2,000 years old. A prehistoric woven mat, probably used to cushion and insulate the knees of an ancient ice gatherer, is still captured in the frozen interior of one such cave.

Through the centuries, the hundred-mile-long trail connecting the pueblos of Acoma and Zuni traversed El Malpais, presenting a formidable passage. With their ice, the caves provided not only respite from the heat but also a source of water. When the ancient icemen came, they chipped off a supply and apparently used fire to melt the precious resource. Nearly every ice-yielding cave contains charcoal from their fires. The drinking water thus obtained was consumed during the trip or sealed in pottery jars and

Betatakin, a thirteenth-century Anasazi village, nestles beneath the cliffs of Navajo National Monument, Arizona.
Jerry Jacka



Heat cached for later use. Today, the Acoma, Zuni, and Navajo who hunt in El Malpais still use the caves to store their butchered meat until they are ready to return home.

The miracle of ice in an oven made of molten rock has engendered a sense of reverence in those who benefit from its presence. The Acoma, for instance, do not approach the caves without performing the requisite rites, including prayers and small offerings—gestures that acknowledge unique gifts, to be used within limits and with proper respect.

The now-dominant Anglo and Hispanic cultures in the Southwest have rediscovered some of the basic principles of the ancients. The homes of these newcomers (who will probably be known to future archeologists as the Plastic Makers) incorporate solar-design features. Although these are primarily aimed at keeping warm in the winter, rather than cool in the summer, most are fairly obvious extensions of Native American strategies.

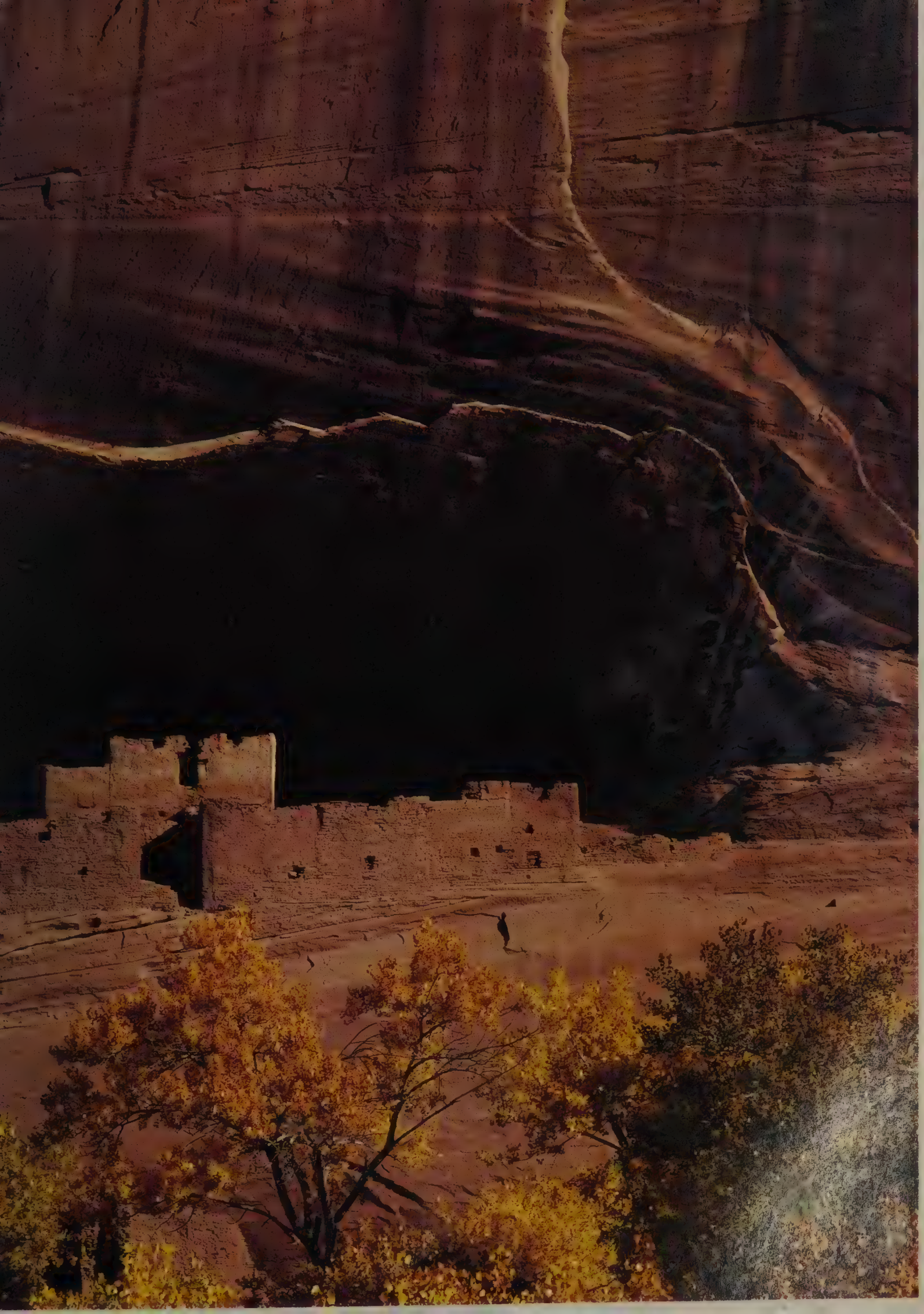
But the newcomers have been slow to pick up on the ancient life style. One important key to keeping cool is choosing when to raise your metabolic rate. Just as the Arabs marveled at the propensity of English overlords to keep mad dogs company in the midday sun, many a Navajo has marveled at the antics of tourists—even some archeologists—who follow an activity schedule developed for use in Northern Europe. □

White House Ruin, right, lies in Canyon de Chelly. Below: Icicles form in a lava cave beneath hot, arid New Mexico badlands.

John D. Brooks







Cool Illusions in the Land of the Rising Sun

by Amanda Mayer Stinchecum

In *The Tale of Genji* (a work of narrative fiction written in the eleventh century by Murasaki Shikibu, a lady of the Japanese imperial court), a nobleman spies on a princess and her ladies-in-waiting. Only semidressed in nearly transparent underrobes, they struggle with a block of ice on a sweltering summer's day:

> Making a great effort, they managed to break it. Each took a piece in her hand. Some even behaved quite vulgarly, placing it on their heads or holding it to their breasts. Another wrapped a bit in paper and presented it this way to the princess, but she held out her very lovely hands and let her wipe them. "No, I'd better not take it," she said, "the dripping is a bother."

The peeping courtier must be rather warm, in his voluminous, layered court robes, but watching the young ladies distracts him from the heat. This is one key to tolerating, even savoring, summer in Japan: create an illusion of coolness by diverting the senses. A garden—even a pocket-sized one—provides a vision of the forest in the deep green of moss and water caught in a stone basin or trickling over rocks. A cast-iron wind bell hangs in a doorway, a slip of stiff paper dangling from the clapper to catch the slightest breeze.

While the streets are still gray with the dawn, Japanese householders and shopkeepers emerge carrying pails of water and dippers, sloshing cool water over the stones or asphalt outside. The dampened surface offers a sense of coolness to the eye, and as the water evaporates, it mitigates the day's rapidly rising heat.

In summer, the owners of old shops and inns or large homes with impressive entranceways take down the dark cotton *noren* curtains that hang in the doorway the rest of the year. They put up others made of crisp, gauzy hemp or other bast fiber—often light in color—that move gently in an otherwise imperceptible breeze. A sink outside the toilet in an elegant inn or restaurant might be loosely filled with sprays of green bamboo or maple leaves: not only the color but also the sound of water splashing on the leaves suggest coolness.

Except in the less-populated mountains and northerly regions, summer in Japan is unrelenting, with warm, humid nights following sultry days. A glass of chilled barley tea, a neatly folded hand towel or handkerchief for wiping off sweat, and a pristine paper fan are the indispensable tools for keeping cool. Even in cosmopolitan Tokyo, a man may be seen standing on a train platform at the end of a hot day, an attaché case by his side and his coat slung over his arm, irritably fanning himself and mopping his brow.

Originally made of cypress slats, the folding fan (*sensu*) is often claimed as a Japanese invention, exported to China as early as the seventh century. Whether a plain white paper fan inscribed in the hand of a famous Buddhist priest, a mourning fan covered in smoky silver leaf with black lacquered ribs, or a fan of colored paper painted with an autumnal landscape, the folding fan delivers an image of coolness along with its breeze.

The rigid fan, known as *uchiwa* in Japan, is of Chinese derivation. In Ozu Yasujirō's classic film *Tokyo Story,* the elderly mother, after an exhausting day in the city, lies on her futon with her ey closed. In one hand she holds an *uchiwa,* fanning herself ev after she appears to have fallen sound asleep. Less often carri out of doors, the *uchiwa* becomes part of the decor of a summ room. At summer festivals, however, when both men a women sport soft, blue-and-white cotton *yukata* robes, it tucked into the obi, or broad sash, just under the knot at the sm of the back, from where it can be retrieved as the need arises.

Japanese-style summer clothing incorporates special fabr that stand stiffly away from the body, allowing the air to circ late. These displace the warmer cottons and tightly woven sil of the cooler months. Bast fiber taken from the inner surface the bark of the ramie plant, a commercially cultivated member the nettle family, is especially prized and retains strong assoc tions with Japan's Snow Country. Woven in wintertime into fine, translucent cloth in Niigata Prefecture (formerly t province of Echigo), it is traditionally bleached on top of t snow in the brilliant sunshine of early spring.

As actually worn by a woman, however, a fine Echigo kimo loses much of its coolness. Underneath she encases herself in least one additional layer of underkimono (plus Western-sty bra and underpants these days), firmly wrapped around the bo and tied with a separate cord. The kimono itself is sashed with stiff obi that barely lets the wearer breathe. Even a filmy si crepe or georgette kimono is worn the same way, creating inviting but deceptive image of coolness. Little wonder mo Japanese women avoid such dress, especially in summer, exce for special occasions (weddings, funerals) and for performi the tea ceremony, traditional dance, and other arts.

Men have an easier time of it. They not only wear less but th also have special summer underwear, made of a crepe cotto and-ramie blend fabric that absorbs perspiration and lets the a pass through it. On summer nights, men freely go out into t streets wearing only their underwear or loosely wrapped in ramie kimono tied with a soft sash.

Like other peoples, the Japanese have their special summ foods and drinks. Ice, preserved in chambers cut into a mou tainside or into the ground, was a summer luxury enjoyed b members of the eleventh-century imperial court. Sei Shōnago an attendant who recorded her observations and personal refle tions, lists, among other "Elegant Things," "shaved ice mixe with liana syrup and put in a new silver bowl" (*The Pillow Bo of Sei Shōnagon,* translated by Ivan Morris). Shaved ice remai a typical Japanese refreshment, these days sweetened with fl vored syrups, condensed milk, or the green, thick tea of the t ceremony (chilled before pouring over the ice), and topped wi sweet azuki beans.

Just as important as real ice is the appearance of ice: froste glass bowls and plates hold everything from chilled fruit sashimi and noodles. Sweets served with the tea of the tea cer mony (which is sometimes whisked up in a tea bowl and poure into a glass over ice) look like ice or chilled water: a colorle glassy, seaweed-based gelatin, ice-cube shaped, contains

A woodblock print, designed about 1800 by Eisui, depicts a young courtesan in early summer, wearing a yukata *robe and holding a nonfolding fan.*
The Nelson-Atkins Museum of Art


松葉屋うち
深し助
美人文色白
一乗亭
栄水画


四條河原夕涼躰
三枚續
清長画

lature goldfish made of sugar; a transparent yellow jelly, its etness offset by a single fermented black bean, is contained delicately patterned brown-and-white clamshell; translu-, opaline noodles made of arrowroot starch (for dipping in a vn-sugar syrup) nestle among chunks of crystal clear ice in a k lacquer bowl.

ummer outings have long been a favorite Japanese way of ing off. Eighteenth-century woodblock prints depict the citi-y of Edo (now Tokyo) and Kyoto, dressed in sheer kimonos fanning themselves, seeking the cool of the evening by vding onto the arching wooden bridges over the Sumida and no rivers. Often the night sky behind them is lit up with fire-ks. A more effective excursion was a trip to Kifune in the north of Kyoto (even now, more pleasant than sulking in a d air-conditioned coffee shop). In a cool gorge rising from banks of a clear-running river, platforms are set out only es above the water from June until September. There diners y white, threadlike noodles called *sōmen,* served over clear nks of ice in a glass bowl. Sunlight filters through screens of len reeds, set up to shield guests from the blazing sun and the es of passersby.

Many urban Japanese (the overwhelming majority of Japan's ulation) live and work in steel-and-concrete buildings with ral air conditioning. But those who can afford to build a se, and those who live in rural parts of the country, adhere to ore ancient life style that follows the changing seasons. "A anese house should be built with summer in mind. In winter possible to live anywhere, but a badly made house is un-rable when it gets hot," wrote the Buddhist priest Yoshida kō more than 650 years ago (*Essays in Idleness,* translated Donald Keene). The main living areas and parlors of the tra-onal house are oriented to the south, to be warmed by direct shine in winter. This alignment also insures that in summer same rooms will be shaded much of the morning and ning, while in the heat of noon they are protected by deeply rhanging eaves.

ile-roofed houses with thin, lath-and-plaster walls, sliding s doors, and wood or metal rain shutters do little to keep out damp cold during the winter months. But in mid-July, when rainy season comes to an end and the full blast of summer's t hits city and country dweller alike, the Japanese house takes a summery aspect. The sliding glass doors (translucent paper ast centuries) and the heavy paper sliding partitions (*fusuma*) separate one room from another can be pushed wide open or n removed. The impermeable winter *fusuma* may be replaced others made of thin reeds, which provide a sense of privacy le allowing breezes to pass from one room to the next.

Warm straw tatami matting is covered with pale blond, sleek s of stripped wisteria fiber, smoother and cooler to the touch. shions covered with heavy silk or warm cotton are stored ay, replaced with thinner ones covered in porous, woven straw risp hemp, ramie, or exotic banana fiber cloth from subtropi-Okinawa, Japan's southernmost prefecture. Blinds of aged nboo, bark-covered wisteria, or reeds are hung from the eaves provide a modicum of privacy and break any intrusive sun-ne into striped shade.

oling off by Kyoto's Kamo River, young women sparklers adrift. The print is part of a late hteenth century triptych by Kiyonaga.
Minneapolis Institute of Arts

At night, however, when everyone is fast asleep and oblivious to artifice, every door and window is firmly closed and bolted; the outer rain shutters are shut as well, allowing not a breath of night air to penetrate the rooms (but ample space for mosquitoes to find their way in). Mosquito nets, still used in some country houses, add yet another layer of suffocating obstacles to passing breezes.

Fear of the night air appears to be a recent invention. Nearly a thousand years ago, activities at the imperial court often continued through the night. In describing her favorite time of day for each season, Sei Shōnagon wrote:

In summer the nights. Not only when the moon shines, but on dark nights too, as the fireflies flit to and fro, and even when it rains, how beautiful it is!

"During the hot months," she also noted, "it is a great delight to sit on the veranda, enjoying the cool of the evening and observing the outlines of objects gradually become blurred." □

A Wonderful Safety Net for Mammals

by Mary Ann Baker

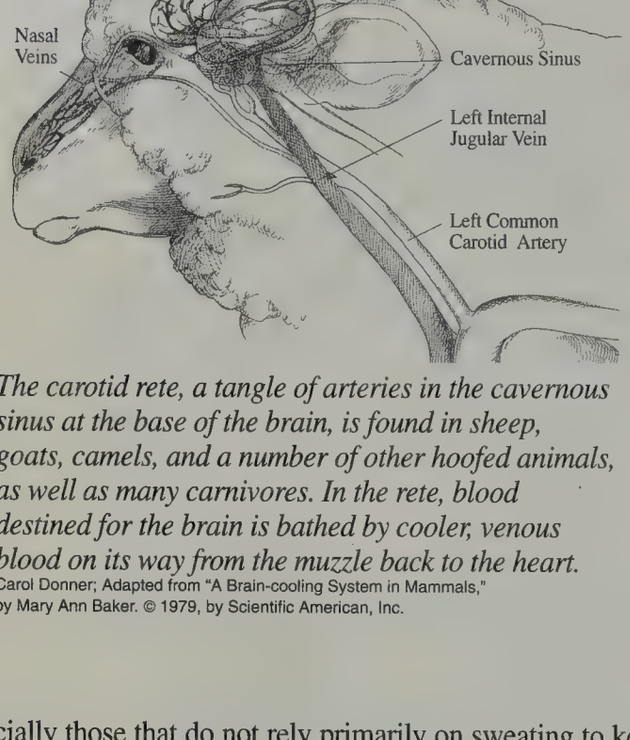
Because early Greek anatomists rarely worked on human cadavers, they sometimes drew false conclusions about human anatomy from their dissections of other mammals. In the heads of sheep and goats, for instance, they came upon a remarkable tangle of small arteries in the cavernous sinus, a lake of venous blood at the base of the brain. The tangle, which eventually came to be known by the Latin phrase *rete mirabile,* or "wonderful net," was assumed for many centuries afterward to be present in the brains of humans as well. Its function was unknown.

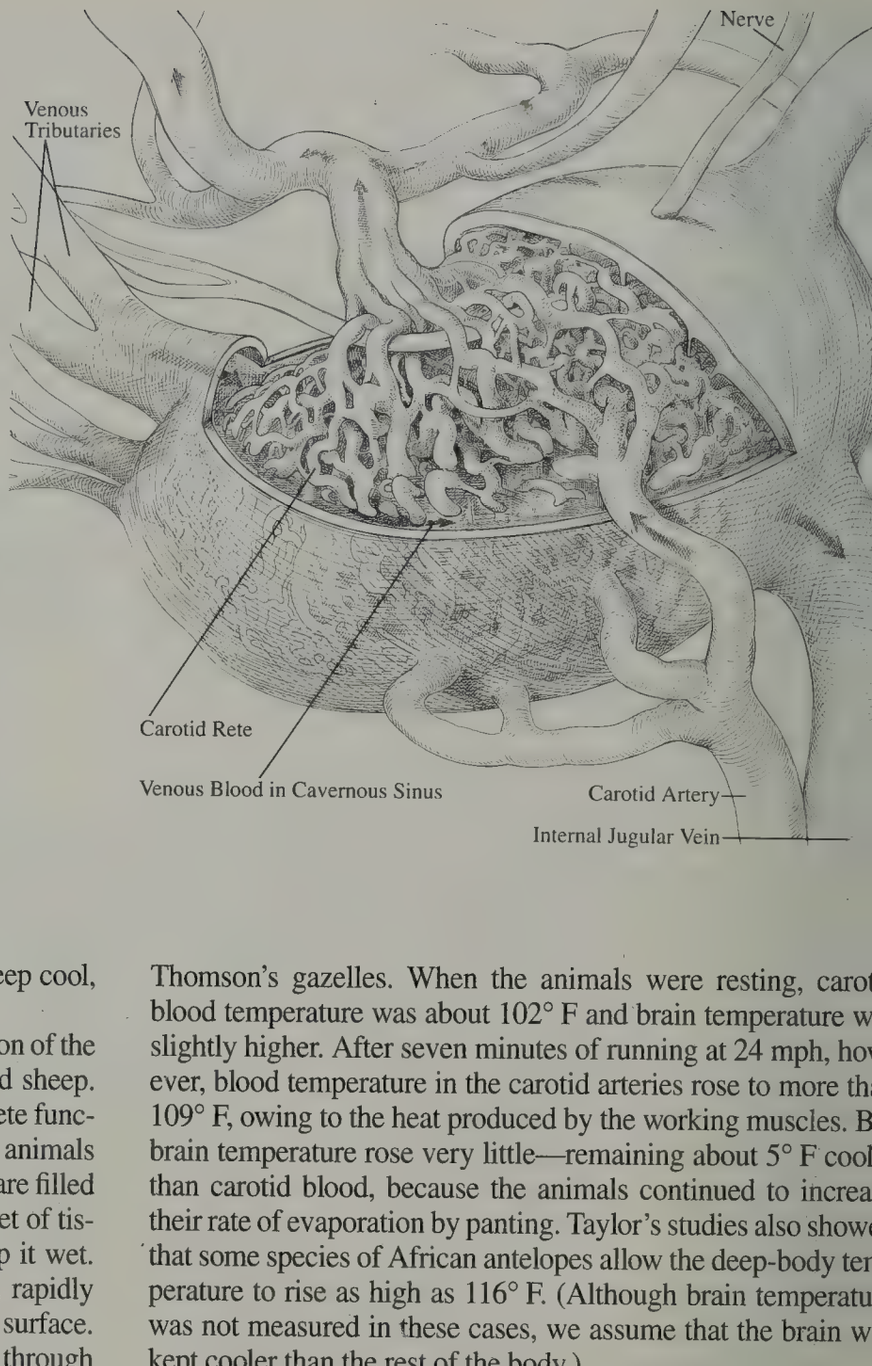
As it turned out, the wonderful net was not a shared element of mammalian brains. Human beings and other primates did not possess it. Neither did rodents or horses. The carotid rete, as we call it today, has been found in two groups: artiodactyls (the order of even-toed hoofed mammals that includes antelopes, camels, sheep, goats, and cows) and the carnivores (including seals and sea lions and wild and domestic cats and dogs).

What is the function of the carotid rete? The first clear experimental evidence did not come until about thirty years ago, when measurements of brain temperature in various mammals showed that the carotid rete works as a heat exchanger—a mechanism to cool the arterial blood destined for the brain.

The brain is one of the most metabolically active tissues in the body, producing large amounts of heat as it carries on its functions. The brain is also sensitive to overheating, and brain functions are disrupted if brain temperatures rise too high. In all mammals, cool arterial blood, flowing at high rates into the brain, serves to dissipate excess brain heat. But in some species, espe-

Heat





The carotid rete, a tangle of arteries in the cavernous sinus at the base of the brain, is found in sheep, goats, camels, and a number of other hoofed animals, as well as many carnivores. In the rete, blood destined for the brain is bathed by cooler, venous blood on its way from the muzzle back to the heart.

Carol Donner; Adapted from "A Brain-cooling System in Mammals," by Mary Ann Baker. © 1979, by Scientific American, Inc.

cially those that do not rely primarily on sweating to keep cool, the carotid rete also plays a crucial role.

Most of what scientists have learned about the operation of the carotid rete comes from laboratory studies of goats and sheep. However, studies of African antelopes suggest that the rete functions in a similar way in wild ungulates. Many of these animals cool themselves mainly by panting. Their long muzzles are filled with a scrollwork of bones, which is covered with a sheet of tissue well-supplied with blood and with glands that keep it wet. Each breath evaporates moisture from this wet tissue, rapidly cooling the blood running in vessels just beneath the surface. Thick-walled, muscular veins then transport this blood through small holes in the skull over the eyes into the cranial cavity, where it enters the cavernous sinus. There, it bathes the carotid rete, cooling arterial blood on its way to the brain. The labyrinthine network of small arteries provides a large area for heat exchange to take place.

What are the benefits of this elaborate system? One answer is that it saves water. The heat-sensitive brain is selectively cooled, while the rest of the body is allowed to heat up. Animals that sweat at high rates keep the entire body cool, as cool venous blood returning from the skin surface to the heart is distributed throughout the circulatory system. But this strategy requires a high expenditure of water.

The panting animal with a carotid rete cools the brain's blood with a minimum of water, since the cool nasal blood goes directly to the cranial cavity rather than to the heart (where it would warm as it mixed with blood from the rest of the body). And by allowing the temperature of the rest of the body to rise above the temperature of its surroundings, the animal can lose some heat without losing water at all—relying instead on radiation of its body heat to cooler objects in the environment.

Physiologist C. R. Taylor of Harvard University has observed some dramatic examples of this phenomenon. Taylor measured temperatures in the brain and in the carotid artery (in the neck) of Thomson's gazelles. When the animals were resting, carot blood temperature was about 102° F and brain temperature w slightly higher. After seven minutes of running at 24 mph, ho ever, blood temperature in the carotid arteries rose to more th 109° F, owing to the heat produced by the working muscles. B brain temperature rose very little—remaining about 5° F cool than carotid blood, because the animals continued to increa their rate of evaporation by panting. Taylor's studies also show that some species of African antelopes allow the deep-body ter perature to rise as high as 116° F. (Although brain temperatu was not measured in these cases, we assume that the brain w kept cooler than the rest of the body.)

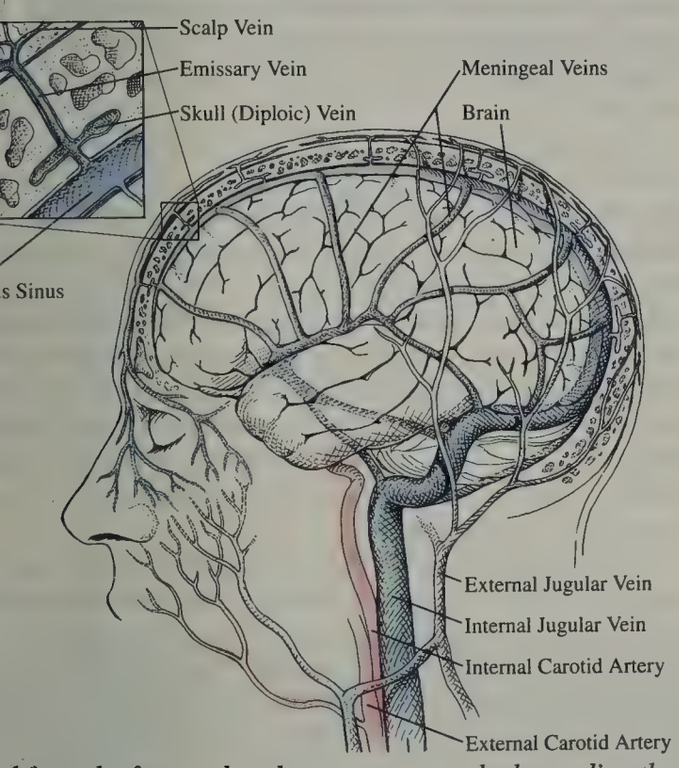
Domestic goats, as well as some wild African ungulates, u both panting and sweating for thermoregulation. When these a imals are not able to drink, they stop sweating but continue pant. Thus, they save water and continue to keep the brain coo Goats deprived of water in hot conditions reduce water loss from both sweating and panting without sacrificing brain coolin by diverting a larger proportion of nasal venous blood to the cr nial cavity and returning less of it to the heart. This suggests th the activity of the muscular veins draining the nose can be a tered by the state of dehydration of the animal.

Both hydrated and dehydrated animals start the brain-coolin process well before brain temperatures reach a level that woul damage the central nervous system. This observation led phys ologist Claus Jessen and his colleagues in Germany to sugge that the cooling process may do more for the animal than prote the brain. It may also reduce the total cost of thermoregulatio In their studies on goats, the Jessen group showed that panting driven by thermosensors in two regions: the hypothalamus (a the base of the brain) and the body core (possibly the viscera o the large vessels near the heart). When the hypothalamic the mostat is kept cool, the total stimulus for panting is reduced, ex tending the range of deep-body temperatures over which the an imal operates without sacrificing water. □

Good Brain Is lard to Cool

Dean Falk

ven a rise of several degrees in body temperature, from 98.6° 07° F, poses a special threat to the human brain, leading lly to convulsions, hallucinations, permanent neural dam- and sometimes death. Because of its large size, the brain it- generates lots of heat, which can accumulate to dangerous s if not dissipated. Fortunately, like the engine of a car, the has a radiator to protect it from overheating—a network of veins that originate in the scalp and face. Although blood ing through these veins can drain directly through vessels de the skull, it can also travel into the braincase (through



d from the face and scalp may return to the heart directly ugh the external jugular vein or by a more circuitous path, ring the braincase and ultimately exiting through the nal jugular vein. The second route enables blood cooled at kin surface to help cool the brain.

Donner

issary veins") and join the blood draining from the brain. process helps cool the brain.

When a person exercises, for example, his or her face will as arteries dilate to bring more blood near the skin surface, ch is cooled by the evaporation of sweat. Much of this extra d, now cooled, enters the emissary veins and is delivered the meningeal veins and sinuses of the dura mater, which ers the brain. From there, some of the blood flows to veins in the surface of the brain itself. As it circulates, the blood oves heat from all these regions. By the time it joins other ve- s blood leaving the skull, it is warmer than the oxygenated, rial blood that supplies the brain. This venous network does not have valves, allowing the blood to move freely as required.

Unlike modern humans, apes lack a venous radiator. The evolution of bipedalism necessitated changes in blood circulation and may have laid the groundwork for its emergence. An examination of fossil skulls, however, reveals that a venous radiator did not arise immediately. It is absent in the earliest-known hominid (*Australopithecus afarensis*) and in some of its successors, the "robust" australopithecines. Brain size remained conservative in these species. But a prototype radiator is present in the "gracile" australopithecines. This is most evident in the greater number of holes in the skull, called emissary foramina, to accommodate emissary veins. I therefore conclude that the gracile australopithecines gave rise to our own genus, *Homo*.

Beginning about two million years ago, the number of emissary foramina in the genus *Homo* began to increase dramatically. Brain size also began to increase rapidly in this group, and these trends continued in tandem until the time of the Neanderthals (about 100,000 years ago). The evolving venous radiator apparently removed a major constraint on the increase of brain size.

Humans are not the only large-brained animals that evolved cranial radiators. Some fifty million years ago, the terrestrial ancestors of whales (including dolphins) began a major change in posture and locomotion that culminated in their becoming exclusively adapted to an aquatic habitat. Like humans, whales have evolved large, highly convoluted brains that generate potentially damaging heat. But unlike humans (and other terrestrial mammals), whales do not receive blood for their brains from the internal carotid and vertebral arteries. Instead, their entire blood supply to the brain comes through an elaborate body of convoluted vessels, called a rete, that originates in the vessels of the thorax and spine. Recently, Tom J. Ford, of Boston College, and Scott D. Kraus, of the New England Aquarium, discovered that in at least three species of whales (right, bowhead, and pygmy right) another rete exists in the mouth. The rete in the mouth is thought to lose heat to ocean water. They speculate that the two retia are connected in some way, and serve to cool blood that supplies the brain. This mechanism is reminiscent of, but distinct from, the arrangement in many mammals adapted to hot terrestrial habitats. Thus radiators may have evolved independently at least four times—in terrestrial mammals with cooling muzzles, in whales, humans, and automobiles. □

Human Ancestors Walked Tall, Stayed Cool

by Pete Wheeler

Hominids, or humanlike primates, first appeared in Africa five to seven million years ago, when that continent's climate was becoming increasingly arid and large tracts of woodland and savanna were replacing the unbroken canopy of the equatorial rain

forest. While the ancestors of chimpanzees and gorillas remained in the moist forests, the hominids started to exploit the more open, drier habitats. The exact nature of the transition remains hidden, because the oldest-known hominid fossils (*Australopithecus afarensis*) are only four million years old. But the intense sunshine in the new environment, combined with a scarcity of drinking water, must have severely challenged the ability of early hominids to regulate their body temperature.

Many savanna mammals do not even attempt to dissipate all the additional heat they absorb during the day, allowing it instead to accumulate within their bodies until nightfall, when they can cool off without expending precious water (*see* "From Its Blood to Its Hump, the Camel Adapts to the Desert," page 30). But this strategy works only if delicate tissues, such as the central nervous system, are protected from surges in body temperature. Most savanna mammals possess special physiological mechanisms to cool the brain—notably the carotid rete, a network of fine arteries near the base of the brain, coupled with venous circulation through the muzzle (*see* "A Wonderful Safety Net for Mammals," page 63).

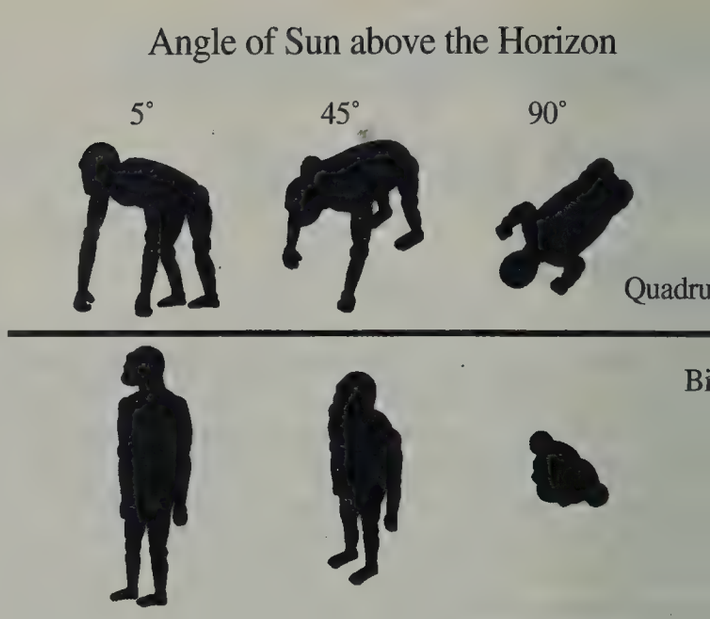
Humans, apes, and monkeys, however, lack these features. Although humans appear to have eventually evolved an alternative mechanism to help cool the surface of their enlarged brains (*see* "A Good Brain Is Hard to Cool," page 65), the first hominids could have prevented damaging elevations of brain temperature only by keeping their entire body cool. Any adaptations that either reduced the amount of heat absorbed from the environment or facilitated its rapid dissipation would have proved highly advantageous.

Walking on two feet—the unique mode of terrestrial locomotion that is widely recognized as the first key development in hominid evolution—conferred precisely these benefits. Bipedalism dramatically reduces exposure to direct solar radiation during the middle of the equatorial day. I have placed scale models of early australopithecines in quadrupedal and bipedal postures to measure how the sun would hit them. These experiments show that when the sun is high, bombarding the earth's surface with intense radiation (because the rays pass through less atmosphere), far less body surface is exposed on a biped than on a quadruped. When the sun is directly overhead, the heat load on an upright hominid is only about 40 percent of that received by a quadruped of similar size.

Bipedalism also raises most of the body well above the ground, so that the skin contacts cooler and faster-moving air currents. This favors heat dissipation through convection. Allowing for variation in environmental conditions and vegetation, I calculate that hominids would have lost about one-third more heat through convection by adopting a bipedal posture.

Finally, human bipedalism at low speeds uses less energy than does either true quadrupedalism or the knuckle walking used by African apes. This reduces both dietary requirements (and the time and effort spent foraging) and the rate at which heat is generated internally as a byproduct of muscular activity.

Taking these factors into account in calculating the overall energy and water budgets of the early hominids, I conclude that bipedalism significantly decreased early hominids' dependence on shade, allowing them to forage in the open for longer periods and at higher temperatures. Bipedalism also greatly reduced the amount of drinking water they needed for evaporative cooling through sweating. I estimate that a knuckle-walking ape, active throughout the day on the savanna, would typically need to drink



On all fours (top row), a hypothetical human progenitor exposes considerable body surface to direct solar radiation, whether the sun is low on the horizon, intermediate, or direc overhead. In contrast, the same creature in a bipedal posture far less vulnerable to the intense rays of the midday sun (bottom row, right).
Pete Wheeler

about five pints of water. Just by assuming bipedal posture locomotion, a hominid of similar size would get by with th pints daily.

Bipedalism appears to be an ideal mode of terrestrial locor tion for a mammal foraging in the equatorial savanna, wh food and water resources are dispersed and far from abund But if so, why do we find bipedalism only in humans? Proba because all other mammals of the African savanna, includ monkeys such as baboons, are descended from ancestors were already true quadrupeds.

In contrast, humans, along with chimpanzees and goril probably descended from tree-dwelling primates that brachiat or swung from branches using their arms. These ancestors w not strongly committed to one particular mode of terrestrial comotion and may have been predisposed to walking upright. they moved into more open habitats, the overheating proble they encountered may have tipped the balance in favor bipedalism. (An alternative possibility is that bipedalism first perfected in the forest habitat for some entirely different r son, and that our ancestors just happened to be preadapted for problems they would encounter on the expanding savanna.)

Following the acquisition of an upright posture, huma evolved in other ways that enabled them to keep cool. Aver body weight rose, slowing dehydration under savanna con tions. Larger hominids would have been able to forage for lon periods, and across greater distances, before needing to drink

Later hominids—members of our own genus, *Homo*— also taller for their body weight than their stockier and rat more apelike ancestors, the australopithecines. By at least million years ago, *H. erectus* had acquired the tall, lin physique, with relatively narrow shoulders and hips, character tic of many human populations inhabiting hot, arid regions of tropics today. A tall, thin body maximizes the skin area availa for heat dissipation, while minimizing the exposure of these s faces to the overhead sun. Longer legs help by raising the bo still farther above the hot ground.

cientists have long reasoned that one of the most obvious unusual human features, the loss of insulating body hair, is adaptation to the hot savanna. Although follicles are still sely distributed over most of the human body, the hairs they duce are so short and fine that the underlying skin is exposed ctly to the flow of air, promoting the shedding of excess heat convection and, when necessary, enhancing the effectiveness weating.

The problem with this hypothesis has always been explaining y humans differ from other savanna mammals, which have ined dense coats of hair. In environments where mammals exposed to strong solar radiation, the coat acts as a shield, re- ting and reradiating heat before it reaches the skin. For most mmals, the loss of this insulation would create more problems it would solve: I calculate that on the savanna, naked drupeds would actually need to drink additional water to e with the extra heat load. For a biped, in contrast, a naked n saves water because so little skin surface is exposed to the . Mainly the head and upper shoulders are exposed, and these be protected by the retention of a relatively small amount of cover. Bipedalism and the strategy of cooling the whole y (rather than just the brain) probably explain why humans lved a naked skin, while other savanna mammals of compa- le size did not.

The stability in body temperature provided by bipedalism and aked skin may have been an essential step in allowing our ge, heat-sensitive brains to evolve further. A parallel to this be seen in the development of modern computers. Informa- n-processing systems—semiconductor as well as biological— erate substantial heat and are vulnerable to damage from rheating. This presents a major obstacle to electronics engi- rs attempting to build ever more capable machines. The cir- ts of the Cray 2 supercomputer, for example, are so densely packed that they must be immersed in a tank of fluorocarbon liquid maintained at about 65° F. As in the case of the evolution of the human brain, the development of such an elaborate cooling system does not inevitably lead to higher-performance machines, but it does make them possible.

As humans spread outward from Africa, they encountered different levels of heat, exposure, and moisture. Many studies suggest that these factors determined, at least in part, the variation we now observe in features as diverse as nose shape, limb proportions, hair structure, skin pigmentation, and eye color. Modern humans inhabiting savanna and desert environments near the equator, such as the Nilotic peoples of Africa and the Australian aborigines, commonly have tall, thin physiques resembling that of early *Homo erectus*. Their skin, especially among groups that have traditionally worn little clothing, is generally very dark, owing to the high concentration of melanin pigment that protects underlying tissues from sunburn and the carcinogenic effects of ultraviolet radiation.

As humans migrated north into colder regions, where retaining heat became more vital, they evolved proportionately shorter limbs, a trend seen in many other groups of mammals. In these populations the skin has lost most of its pigmentation, apparently because of the milder impact of ultraviolet radiation at high latitudes. The reduction in pigment may simply reflect the relaxation of the need for it, or it may have been demanded to allow sufficient penetration of ultraviolet radiation (which humans need to synthesize essential vitamin D).

As they colonized—or recolonized—tropical rain forests, humans faced another obstacle. Although the canopy affords shade, the humidity inhibits the evaporation of sweat. The resultant dependence on convective heat loss favors a body form with a large surface area relative to volume. Unfortunately, the tall, linear physique that works so well in open equatorial habitats is not practical when negotiating dense vegetation. A better solution may be a small body, exemplified by the Mbuti Pygmies of the Congo Basin, who benefit from a high surface-to-volume ratio and can move with agility across the forest floor. □

mbers of the El Molo tribe of herders and fishers cross the d flatlands southeast of Kenya's Lake Turkana.

rt Caputo



Between Rock and a Soft Place

Should ice cream be served hard or at the melting point?

by Raymond Sokolov

Elizabeth David died last year, leaving many legacies to people interested in the history of food and its preparation. Her books on France and Italy, on spices and on bread, set a standard for scholarship and sensitivity for the burgeoning tribe of gastroethnographers who followed her.

Perhaps one of them will complete her unfinished last work, a study of the origins of ice cream. Some of it appeared in a series of articles in *Petits Propos Culinaires,* beginning with the very first number of that learned, yet spry, publication in February 1979.

"Hunt the Ice Cream" scrutinized three early English ice cream recipes. In the next few issues of *PPC,* David looked into manuscript evidence about such related arcana as *fromages glacés* and the caves where ice was stored before refrigeration. She delved into the greater mysteries of premechanical ice cream freezing and the containers and molds and *bombes* from the dawn of modern ice cream in the eighteenth century and earlier.

David was so prolific in this area that *PPC* found itself happily embarrassed by the richness of her output. The editors were "waist-deep in ice cream," as they put it in a note in *PPC* announcing a special supplement to incorporate a treatise on "Ice Cream and Water Ices in 17th and 18th Century England," by W. Stallings, Jr., a pewter collector who holdings in antique ice cream molds led him to do historical research.

I began rereading David's ice cream says as a small act of piety and then fou myself swept up in her learned inqui Like all first-rate scholarship, hers (a Stallings's) raises many questions. It me wondering, exactly how did our fo bears serve ice cream?

I am not talking about the look of it about visual presentation in gener David and her sources, with their many lustrations, tell us a good deal about th And she was able to paint a very speci



Three women and a girl eat ice cream in Chichicastenango, Guatemala
Miriam Lefkowitz; Envision

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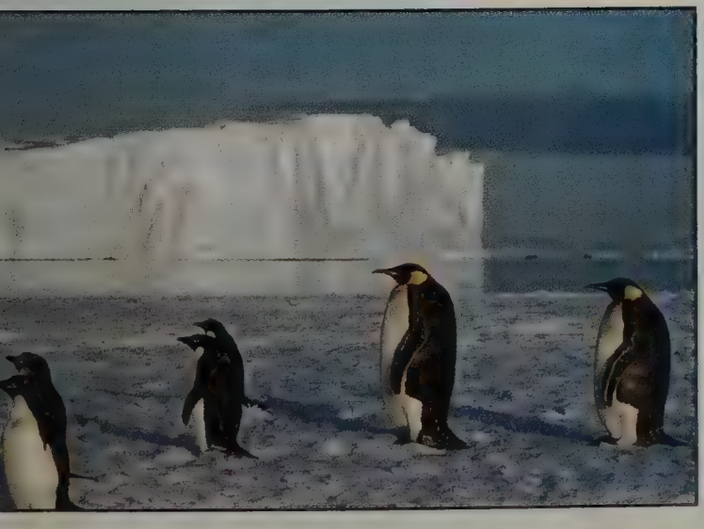
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picture of how ice cream was made, even reprinting old recipes so that we can have a pretty fair idea of how a French chef's marzipan *tourte* stuffed with pistachio ice cream might have been put together in 1734 and how it might be reproduced today.

What is largely missing from the *PPC* ice cream boomlet of those days is something so simple that cookbook writers then and even now hardly mention it. Should ice cream be served (relatively) hard or (relatively) soft?

Even the earliest recipes indicate, by their methods, that rock-hard ices or ice creams with nuggets of crystallized ice in them were considered undesirable, just as they would be now. David quotes La Varenne's recipe for orangeflower snow (*neige de fleur d'orange*) from his *Nouveau Confiturier* (ca. 1696): "You must shake it from time to time for fear it will freeze into a solid lump of ice (*glaçon*); it will take two hours."

Common sense tells us that no one ever intentionally put rock-hard ice cream in front of guests. On the other hand, there are early and contemporary examples of ices meant to be served as slush or, in the Near East, as cold drinks. But these are not, to my mind, true instances of normal ice cream or of the problems of serving temperature and solidity it presents.

To specify a clear and universal standard is clearly impossible, and not only because fashions and tastes change or vary from person to person. (This starts in childhood as a split between those who bite at ice cream in cones or on sticks and those who lick them.) This is especially so since different kinds of ice creams are chemically and physically different enough to create individual criteria and freezing characteristics.

Nevertheless, it should be possible to limit the investigation to mainstream cream/milk/egg/sugar ice cream and then look for consensus on serving consistency in printed sources and to conduct tastings with identical batches of ice cream served at different temperatures.

What, then, do modern authorities writing scientific recipes have to say on this matter? Madame Sainte-Ange's bible of traditional French high bourgeois cooking (*La Cuisine de Madame Sainte-Ange*) is not much help. In the many astute pages she devotes to ice cream, the only specific indication she gives on the hard versus soft question is this general observation: "An ice cream may be served either molded or *en rocher,* arranged in spoonfuls [scoops?] piled one on the other; or by the spoonful in individual ice cream dishes. In the last two cases, the ice cream melts more rapidly than a molded ice cream, because it is less cold. But this relatively moderate temperature is appreciated by most guests."

Shona Crawford Poole in *Iced Delights* (1987) takes a roughly similar moderate position: "The aim is to soften it enough to scoop and serve."

These sources and many other mainstream cookbooks are essentially advising the minimum softness necessary to serve the ice cream and to get a spoon into it without effort. They never come to grips with the essential question: What degree of softness produces the best taste? Or does this parameter matter at all to the perception of flavor intensity?

I have been able to find only one published opinion even indirectly relevant to this question. In the lead-in to her recipe for a Mogul watermelon sherbet, Julie Sahni (*Classic Indian Vegetarian and Grain Cooking,* 1985) writes: "Traditionally, it is served as an ice that is sipped, like a frozen daiquiri, while it melts under the blistering north Indian sun."

Although Sahni doesn't actually say that she prefers the taste of melting, sipped sherbet, she does at least call attention to a cultural preference. But in the next sentence she goes on to say that in our cooler climate, solider sherbet eaten with a spoon makes more sense.

Cultural relativism may be the best way out of the puzzle, but my own experience with ice cream in Western settings made me suspect that the ideal way to eat ice cream is as soft as possible—at the very edge of melting, before it begins to puddle on the plate, but only just before. This entirely subjective point of view rests on two extremely vivid encounters.

In 1972 while wandering in the Savane, the main square of Fort-de-France, Martinique, I bought banana ice cream from a woman standing in direct sun with a large container sitting in a tub of ice. It was late in the day; she had virtually sold out and the ice cream, when she removed the lid, looked almost like soup. But by searching energetically, she was able to produce two scoops still cold enough to hold their shape. I consumed them quickly with a plastic spoon. They were sublime. In the same year I was in a small and excellent old-fashioned restaurant in Lyon. On the table with the other desserts were several metal containers of ice cream surrounded by ice. The hazelnut ice cream that I ordered was perfectly soft, almost liter melting. Its taste was extraordinary.

Were these reactions purely circu stantial? Would those two ice creams h been just as good if slightly harder? Ob ously I can't say. But to test my very str impressions that their softness was a s of their organoleptic perfection, I recer

To Ice Cream

(From Nathaniel Bailey's *Dictionarur domesticum* [1736], quoted by Elizabeth David in *Petits Propos Culinaires I,* February 1979)

Fill tin icing pots with any sorts cream you please, either plain or swee ened, or you may fruit it: shut the po very close; you must allow three pound of ice to a pot, breaking the ice ver small; laying some great pieces at th bottom and top.

Lay some straw in the bottom of pail, then lay in the ice, putting i amongst it a pound of bay salt; set i your pots of cream, and lay the ice an salt between every pot, so that they ma not touch; but the ice must be lai' round them on every side; and let a goo quantity be laid on top; cover the pa with straw, set it in a cellar, where n sun or light comes, and it will be froze in four hours time; but you may let stand longer; and take it out just as yo use it; if you hold it in your hand and will slip out.

Elizabeth David's Apricot Ice Crean

(Slightly adapted from *Summer Cooking,* Penguin, 1965)

1 pound fresh apricots
3 ounces (½ cup) sugar
¼ pint (British measure; ½ cup plus tablespoons U.S.) double cream (U.S. heavy)

1. Halve and stone the apricots. Stean them until soft and sieve them. Whe cold, add a syrup made from th sugar and ¼ pint (½ cup plus 2 table spoons U.S.) water simmered for 1 minutes. Chill.
2. Whip the cream.
3. Immediately before freezing add th whipped cream. Freeze in foil-cov ered ice-cube trays for 2 hours, stir ring twice during the process. (Davi refers to electric and mechanical ic cream makers elsewhere in *Summe Cooking* as an alternative to thi method.)

To make a firmer ice, the cream ca be cooked to a thin custard with th beaten yolks of 2 eggs. When cool, mi the apricot purée with its syrup into th cream custard. Add also a few of th apricot kernels, skinned and crushed.

pared several samples of Häagen-s vanilla and chocolate ice cream at ous stages of hardness ranging from barely spoonable to completely ed. I chose Häagen-Dazs because it is ghly consistent product and because it es as close as commercial ice cream to top quality handmade ice cream—ross chemical tricks, no crass aeration. Häagen-Dazs sells its vanilla and colate in small containers that lend nselves to sampling and that react to nge in ambient temperature more kly than larger batches.

or the experiment, I left a vanilla and a colate container in the freezer at ghly 15° F. I put one of each flavor in efrigerator at roughly 44° F. And I set a vanilla and chocolate on a kitchen e. It was a cool evening and the air perature measured about 62° F.

fter an hour, I opened all the contain- Those that had been in the freezer d just barely be sampled with a large on, but they became slightly easier to k as the testing progressed (the entire eeding lasted about fifteen minutes. refrigerated pair had reached the con-ional ideal. A spoon went easily in but were still entirely solid and nondrip-ping. The room-temperature pair were marginally liquid but it was no trouble to extract a spoonful of something that was still solid enough to be called ice cream and not soup.

I liked them all, but they did definitely seem to me to present an informal gradient showing an inverse relationship between solidity and taste: The more solid, the less dramatic the taste. When pressed very hard, my wife agreed with this view, but insisted that she found the "room-temperature" samples inferior because they "weren't ice cream."

What this admittedly very informal and limited test suggests is that cold tends to reduce the intensity of flavor in ice cream, but that for some people (my suspicion is that this holds true for most people and that I am an exception) the texture or mouth feel of ice cream is very important, perhaps slightly more important than pure flavor.

This is a surprising result, since most of us have probably assumed that ice cream was interesting primarily as a vehicle for pure, almost abstract, flavor. Texture in ice cream was a secondary matter, and when it was considered at all, the ideal was invariably smoothness, a perfect absence of texture in fact (or to put it another way, an undistracting backdrop for the circus of flavors at the ice cream store).

I shall be very interested to hear from other people who try this experiment, to see if they agree or not. In the meantime, I propose a thought experiment. Remember the last time you made ice cream at home? There came a time when the crank couldn't be turned or the electrical freezer had ground to a halt. The half-frozen ice cream now had to be transferred to another container to be "seasoned" in an ice pack or in the freezer until it hardened to the consistency of "real" ice cream. But after you completed the transfer, the dasher or paddle that had been turning the ice cream inside the freezer had very soft ice cream left on its blades.

When I was a child, I was given the dasher to lick. I continue this habit as an adult (I mean I lick it myself; children can wait). No doubt you have done the same. If you are like me, this is the true moment of ice cream pleasure. The harder, "real" ice cream is never as good.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.

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Stay, Lady, Stay

On an August afternoon, atop a mountain in Arizona's Prescott National Forest, hundreds of ladybird beetles, or ladybugs, lazily congregate on a lichen-spattered boulder—where they may remain for as long as nine months. A wide-ranging species, these polka-dotted predators live in a variety of habitats. In Arizona's lowlands, ladybird larvae hatch at the end of spring and feed on aphids for a month before they pupate and transform into young adults.

Most years, aphids become scarce as the fields grow dry and hot, and the newly matured, hungry beetles fly miles away to cool mountain slopes, where they grow fat on pollen. Afterward, they gather in dense aggregations on mountain summits, seeking out rock crannies that provide shade and moisture. Lethargic through summer and fall, they can live off their fat right through the winter, protected from freezing snowstorms within the same snug shelters that shielded them from summer's heat. Upon waking in the spring, ladybirds mate before returning to the lowlands to lay their eggs. Once again ravenous, they resume feeding on the new crop of aphids; a single ladybird may eat as many as five thousand during its lifetime.

During the ladybirds' dormant periods, human "pickers" scoop up millions of them for sale to aphid-plagued farmers and gardeners. But entomologist Kenneth Hagen, of the University of California at Berkeley's Division of Biological Control, believes that the hibernating ladybirds are useless for pest control. Interrupted in their yearly cycle, Hagen says, the beetles' instinct is to disperse without even searching for food locally. Fleeing the fields for which they were intended, they scatter on the winds.—*R. M.*



Photograph by Whit Bronaugh



Michael D. Robinson (page 28) is a native of Arizona and earned his B.S. in zoology, his M.S. in ecology, and his Ph.D. in desert animal ecology from the University of Arizona. His fieldwork and teaching have taken him to Namibia, Venezuela, and Kuwait. He is happiest exploring remote desert areas. Currently an associate professor of biology at Sultan Qaboos University in Oman, Robinson is studying the diets of plant-eating lizards and the thermal biology of sand dune beetles. He is an avid windsurfer and catamaran sailor.

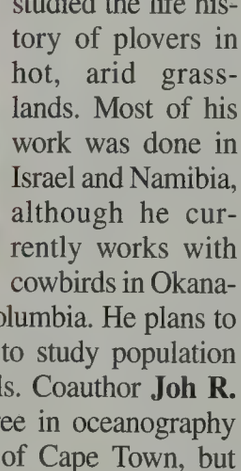


Trained in Holland in veterinary medicine, with a speciality in physiology, **Reuven Yagil** (page 30) returned to his native Israel in 1970 to analyze the unique properties of camel blood. He gave himself six months to complete the project. Today, more than twenty years later, he is still working with camels: researching the medicinal properties of camel milk and setting up stations in the Sudan, Kenya, Somalia, and Ethiopia to teach tribal peoples camel management. Yagil, who began by studying a single camel, "Golda," now works with a herd of fifty at the desert laboratory of Ben-Gurion University of the Negev.

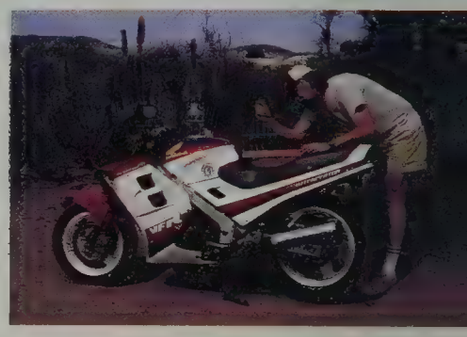




David Ward (page 42) has done research in desert areas ever since he was a Ph.D. candidate at South Africa's University of Natal, where he studied the life history of plovers in hot, arid grasslands. Most of his work was done in Israel and Namibia, although he currently works with cowbirds in Okanagan Valley, British Columbia. He plans to return to the Negev to study population genetics of land snails. Coauthor **Joh R. Henschel** has a degree in oceanography from the University of Cape Town, but more recently has pursued dry-land interests, earning a Ph.D. in zoology from the University of Pretoria. He was inspired to go to the desert after watching a television documentary about the Namib, which showed a species of spider that cartwheels down the dunes to escape predatory wasps.

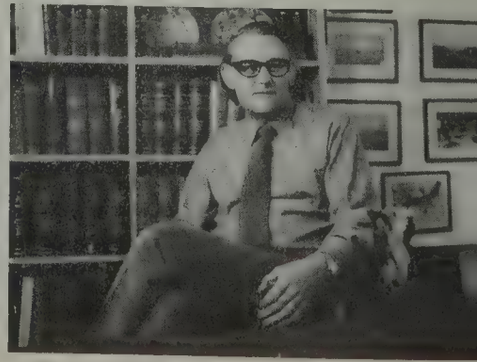


In 1982, as part of a joint study on responses of native Australian plants to heat and water stress, botanist **John S. Pate** (page 36) became interested in the many groups of down under plants with aerial stilt roots. A graduate of Queens University in Belfast, Northern Ireland, Pate now teaches at the University of Western Australia—a few hundred miles from the stilt plant habitats he loves to explore. His research interests include the use of carbon and nitrogen by herbaceous plants, the physiology of plant transport systems, and responses of plants to fire.



After graduating from the University Utah, **Eric C. Toolson** (page 37) earn his doctorate in zoology from Arizo State University in 1976. His studies of cadas, temperature regulation in insec ecological genetics, and arthropod lip biochemistry have involved fieldwork Arizona, New Mexico, Mexico, and Au tralia. While studying the water and te perature regulation of cicada species in t southwestern United States, he made t unexpected discovery that the insec sweat—opening up a previously unknow area for physiological research. When n scrutinizing insects, Toolson enjoys bac packing, reading, astronomy, and "ridi motorcycles at excessive velocities."

John Cloudsley-Thompson (page 3 is a zoologist, physiologist, and ecologi Born in 1921 in India, he has studied a taught at universities in the Suda Kuwait, Nigeria, and England, where he emeritus professor at the University London. An expert on reptiles, mites, sp ders, and insects, he is best known for h investigations of animal migrations, dese adaptations, the biology of arid zones, a day–night (circadian) rhythms in anim behavior.



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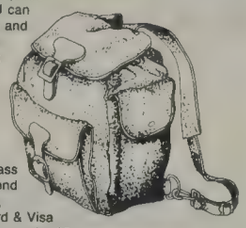
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"Only mad dogs, Englishmen (that's me), and *Ocymyrmex* go out in the midday sun," says **Alan C. Marsh** (page 43) by way of explaining how he became interested in the Namib's heat-loving desert ants. Since Namibia's independence, Marsh has turned his attention away from pure research to training local people in sustainable development projects. On his compound in Windhoek, which he and his family share with a dairy cow, some milch goats, and chickens, Marsh uses photovoltaic energy to lift groundwater and power the house, and solar energy to heat the water.



As his photo suggests, **Neil F. Hadley** (page 44) is an avid fisherman. He received his B.S. in biology from Eastern Michigan University in 1963 and his Ph.D. in environmental physiology from the University of Colorado in 1966. His studies of desert darkling beetles and their novel way of keeping cool by covering themselves with wax followed his research on how waxes in insect and spider cuticles form a waterproof barrier. He is currently a professor of zoology at Arizona State University, where he juggles administrative duties with research. Hadley's fieldwork has taken him to the North Island of New Zealand to research tiger beetles and to the Colorado Rockies to study alpine grasshoppers.

Lloyd Spencer Davis (page 48) h spent six summers in Antarctica studyi the behavior of Adélie penguins and also well acquainted with the yellow-ey penguins that come ashore to breed on t islands of his native New Zealand. He is a senior lecturer in zoology at the University of Otago in Dunedin, New Zealand and is about to embark on a new project as scriptwriter and director of a documentary on penguins produced by New Zealand television. Davis is the author of *Penguin: A Season in the Life of the Adélie Penguin,* which will be published in England by Pavilion this October.



While studying to become an oceanographer, **Russell E. Shea** (page 47) gained real appreciation for the seabirds he observed feeding miles from shore and shifted the course of his studies to seabird breeding ecology. Now an associate professor of biology at Randolph-Macon College in Ashland, Virginia, Shea, in collaboration with Robert Ricklefs of the University of Pennsylvania, is investigating the evolution of avian growth rates. One of their goals is to explain why some birds are born relatively well developed and grow slowly, while other chicks hatch with little mature skeletal muscle and grow quickly.





Deborah M. Brosnan (page 51) knew
he time she was ten that she wanted to
y marine creatures. Growing up on the
t coast of Ireland, she spent her sum-
s playing in tide pools and watching
r resident crabs, anemones, and
ets. An assistant professor of biology
Lewis and Clark College in Portland,
gon, Brosnan is currently studying
ine plant–animal relationships and the
cts of human activity on shore ecology.
is also an ardent promoter of marine
servation and education.



Bernd Heinrich (page 53), shown with
est of ravens, is a frequent contributor
Natural History. His insect studies
an when he was a young boy; by age
en he was keeping bees and collecting
ects. Heinrich's first work on ther-
regulation was with moths, then with
mblebees. His research on how these in-
ts keep warm enough to go out and find
d led to his study of their foraging be-
ior. More recently, he has branched
o ornithology. He did two years of field-
rk in Africa, and has traveled to various
pical and arctic locations, but Maine is
favorite locality. A professor of zool-
y at the University of Vermont, Hein-
n is on sabbatical in Maine studying the
iobiology of ravens.

PAPUA NEW GUINEA

Journey to the Last Unknown
February 16 - March 1, 1994



New Guinea boasts an incredible variety of natural wonders: jungle mountains, vast river systems and volcanic islands. Its long isolation has aided the evolution of unique wildlife and cultural traditions of such striking diversity that they are a reminder of just how unspoiled the country remains. This February, we invite you to join a small group of American Museum travelers and an ornithologist and an anthropologist as we explore Papua New Guinea.

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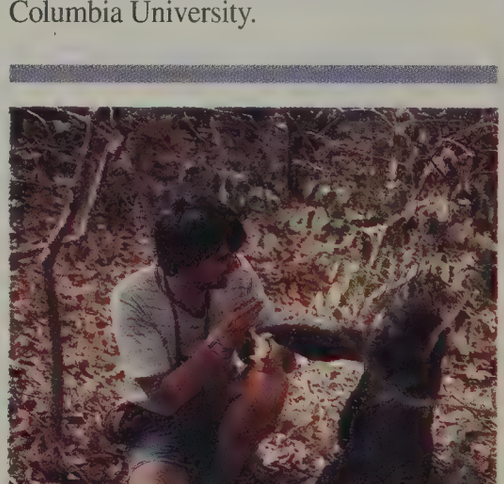


Mary Ann Baker (page 63) is professor of biomedical sciences at the University of California at Riverside, where she teaches neuroscience to first-year medical students. Her interest in physiological responses to heat began in the 1960s, when she was a student "volunteer" in a laboratory study of the sweating response in women. Recent work has focused on the relationship between thermoregulation and body-fluid balance in domestic animals, and she has just finished a new study of the function of the carotid rete in exercising goats. Some of her subjects (pictured above) have retired to a small farm in Redlands, California, where Baker lives with her husband, biologist Vaughan Shoemaker. New administrative duties—Baker is interim program director of Riverside's Division of Biomedical Sciences—mean she has little time for her favorite activity, horseback riding.

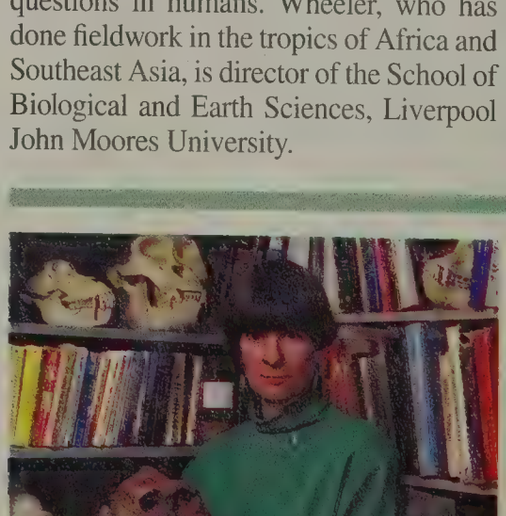


Whit Bronaugh ("The Natural Moment," page 74), a thirty-six-year-old nature photographer from Arlington, Washington, spent a summer afternoon hiking up a mountain in Arizona's Prescott National Forest. On reaching the summit, he chanced upon thousands of ladybird beetles congregating in an area about fifteen feet square. He returned the next morning, when they were more tightly packed and too cold to move, and photographed them in natural light using a Nikon F3 with a 105mm macro lens. "Now that I know the types of places to look," says Bronaugh," I have sought out ladybirds in canyons of the Sierra Nevada as well as on mountain peaks." Current projects include photographing tropical rain forests and old-growth forests.

Amanda Mayer Stinchecum (page 60), who reported on "Enduring Cold the Japanese Way" for *Natural History*'s October 1981 issue on keeping warm, has often experienced summer in Japan. Based in New York City, she is an independent scholar and writer, as well as a research fellow at the Institute for Okinawan Studies, Hōsei University, Tokyo. Her current investigations center on textile production and its relation to the poll tax system in Ryūkyū (present-day Okinawa) during the period 1600–1900. In the future she plans to focus on Okinawan culture in transition, documentating how clothing and textiles reflect Japanese and U. S. subjugation of that island. Stinchecum received her doctorate in classical Japanese literature from Columbia University.

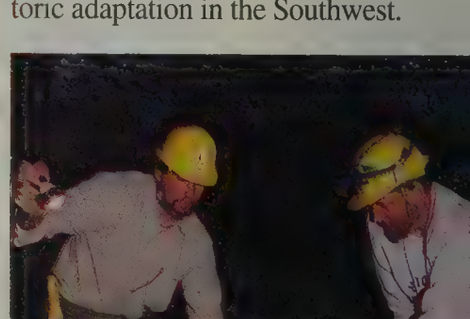


For his doctorate in zoology, **Pete Wheeler** (page 65) investigated metabolic aspects of the evolutionary transition between coldblooded reptiles and warmblooded mammals. His studies of the brain-cooling systems of large dinosaurs subsequently led him to pursue related questions in humans. Wheeler, who has done fieldwork in the tropics of Africa and Southeast Asia, is director of the School of Biological and Earth Sciences, Liverpool John Moores University.





National Park Service archeologists s
tioned in Santa Fe, New Mexico, **Danie
Lenihan** and **James E. Bradford** (pa
56) claim that, in harmony with the en
ronment, their manuscript was "prepa
and submitted from a shady room on
north side of an earthen house." In
photo, Lenihan (right) and Bradford (le
examine a prehistoric mat preserved in
ice of a cave in New Mexico. Their c
league Charles Haecker also contribu
to the description in this issue of preh
toric adaptation in the Southwest.



Dean Falk (page 65) formulated h
"radiator" theory of human brain evo
tion in the course of her research on t
human fossil record. A professor of a
thropology at the State University of Ne
York in Albany, Falk has worked in mus
ums in Africa, Europe, and America a
has taught human gross anatomy and ne
roanatomy. She is currently working on
project about dolphins, chimpanzees, a
the search for extraterrestrial intelligenc

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NATURAL HISTORY Vol. 102, No. 9, September 1993

COVER: *A tassel-eared squirrel chews the inner bark of a ponderosa pine twig. Story on page 44. Photograph by William Ervin.*

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LETTERS

MEXICAN SUN FOOD

In "Sun Food" ("A Matter of Taste," May 1993), Raymond Sokolov observes that while Americans celebrate February 2 as Groundhog Day, Europeans celebrate the day as the Christian feast day called Candlemas. On that day, Sokolov tells us, it is customary to eat pancakes or crêpes.

I may add that Candlemas is celebrated outside of Europe, too. In Mexico, February 2 is the day of La Candelaria, and this day has its special food there, too: tamales, a rather faithful version of which is surely familiar to Americans who have eaten in Tex-Mex restaurants.

Four weeks before La Candelaria, on January 6, extended families gather for the Feast of the Epiphany. There, they share the Rosca de Reyes, or "Roll of the Magi," an O-shaped bread that hides one or more tiny figurines representing the infant Jesus. Each person must cut a slice of the roll, and those who find figurines in their slices will have the obligation of organizing the feast of La Candelaria and of providing the tamales for it. Sadly, this tradition is rapidly disappearing.

ALFREDO CUEVAS
Princeton, New Jersey

EXTINCTION DISTINCTIONS

Unfortunately, the blaauwbock's demise in 1799 was not "the first extinction of a large-bodied mammalian species in historic times," as stated by Stephen Jay Gould in your May issue. That sad distinction belongs to Steller's sea cow (*Hydrodamalis gigas*), which was hunted to extinction for its meat *circa* 1768. It also surpasses the blaauwbock in shortness of elapsed time from discovery (1741) to extermination (twenty-seven years), in amount of scientific data recorded, and in abundance of preserved skeletal material, not to mention in body size (about twenty-five feet in length and more than four tons in weight).

Moreover, the blaauwbock's extinction was the loss of but a single species, whereas that of the sea cow represented the end of its genus and subfamily and also entailed the extinction of at least two species of parasites. Therefore, consi
ing the sea cow's genealogical remote
and striking differences from all other
ing creatures (see *Natural History,* Fe
ary 1946 and April 1987), it was a gre
loss to nature's overall diversity than e
that of the justly lamented blaauwbock

DARYL P. DOMN
Washington, D

Stephen Jay Gould states that
blaauwbock was the first large-bodied
imal to become extinct in historic time
always thought that this distinction
longed to the aurochs, the wild forest
tle of Central Europe that became ext
in the seventeenth century.

MARC RU
Brooklyn, New Y

STEPHEN JAY GOULD REPLIES: *Mea cu*
on Steller's sea cow: I am a victim of
very parochialism I often deride. I
equating mammals with terrestr
creatures and totally forgot about
marine representatives. The identificat
of the auroch is a matter of considera
dispute, but most experts consider it
ancestral form of modern cattle an
member of the same species, *Bos tau*
Therefore its death did not remov
species.

LEFT-HANDED ADVANTAGE?

"The Right and the Sinister" (J
1993), an otherwise informative artic
cited unsubstantiated examples of pr
ucts that discriminate against left-hande
At least two of the four cases cited
bogus—doorknobs and keyboards.

For every case of a doorknob being
the "wrong" side when someone enter
room, it will be encountered on the opp
site side when exiting. Therefore, do
knobs are "left-handed" in 50 percent
the occasions of use. The article states t
about 10 percent of the population is le
handed, so it would seem that left-hande
are favored, not slighted, in this instanc

Similarly, the layout of the standa
QWERTY keyboard was designed for u
on a mechanical typewriter. In order

p fast typists from causing the type
ıs to hit one another, the keyboard was
:ntionally laid out to cause slower key
)kes. This was accomplished by having
most frequently used letters (*e, s, t,* and
operated by the left hand. Right-han-
's would presumably find these keys
der to manipulate. Since computer key-
ırds are no longer limited by mechani-
delays, left-handers have an edge over
hties, not a disadvantage.

RON SHATTIL
Oakland, California

DDLER GOOF

Boy! Are you going to get letters on this
e! On page 37 of the July 1993 issue,
o fiddler crabs are illustrated with the
her unfortunate caption that they "use
ir small cutter claw to stabilize prey and
large crusher claw to break the prey's
rd shell." Fiddler crabs are essentially
tritivores or herbivores. The small, spat-
ıte claw is used to carry particles to the
outhparts, where they are manipulated,
hile a row of remarkable, spoon-shaped
tae scoop out algae and microscopic or-
nisms found in the mud or left by the re-
ating tide. In fact, in the upper picture,
u can see the little discarded mud balls
indicative of fiddler crabs.

The large, major cheliped (claw) is es-
ntially a signaling and sparring ap-
ndage in male fiddler crabs (females
ve just the two, small, minor chelipeds).
ales wave it up and down in a semiritu-
ızed motion (fancifully described as
ddling") that appears to be species-spe-
ic, in order to attract females to their
rrows, where they then mate with them.

ROBERT H. GORE
Naples, Florida

UTTERFLY ROUND TRIPS

As a scientist currently researching but-
rfly migration, I was gratified to read
Butterfly Mass Transit" (June 1993).
our coverage will perhaps spark in-
eased interest in a fascinating but poorly
derstood phenomenon.

I would like to offer three pieces of new
formation on what appears to be an
verwater, trans-Gulf flyway for the
onarch butterfly, probably the only spe-
es of butterfly with a true (two-way)
anscontinental migration.

First, each October thousands of mon-
chs depart from the southwest coast of
ouisiana on a more or less straight-line
oute to Tamaulipas, Mexico, an over-
ater distance of 400 to 500 miles. Sec-
nd, the migrants seem to be particularly



Migrating monarch butterflies pause on a gas production platform off Louisiana's coast.
Gary Noel Ross

sensitive to magnetic fields (monarchs possess magnetite, probably an internal compass) and often home in on offshore oil rigs (which produce artificial magnetic fields). Third, many of the offshore migrants continue to fly long after dark—a phenomenon hitherto unreported for any species of butterfly.

GARY NOEL ROSS
Baton Rouge, Louisiana

WHO READS *Natural History*?

As recent authors, we gained some insight into our audience from the variety of responses to our article, "Pistil-packing Flies" (April 1993). Among the messages from friends and relatives came contacts from long-lost friends. *Harper's* magazine called about using one of the pictures (the pink fly on a yellow flower), as did the author of a textbook on the physics of light (for the reflection and interference patterns from a fly's body and wings). Readers asked for advice on how to photograph insects on flowers, where to get fluorescent dusts for marking flies, information about particular fly species, where to get copies of the photographs, and for details on the feeding behavior and digestive abilities of flies. *Natural History*'s audience is diverse and interesting!

DAVID W. INOUYE
College Park, Maryland
CAROL A. KEARNS
Boulder, Colorado

HOW MANY HUNTERS?

In his interesting article "The Bambi Syndrome" (June 1993), Matt Cartmill presents an essentially fair and balanced account of this controversial and emotion-charged subject. However, as a wildlife biologist and game manager (now retired) I must question some of his statistics.

Cartmill states that in 1982, hunters spent only 109,000 *hours* hunting on United States public lands, and that in 1990 the total was less than half that amount.

But according to the *1991 National Survey of Fishing, Hunting and Wildlife-Associated Recreation* (the latest updated version), 14.1 million Americans hunted on public lands, for a total of 65 million hunter-days.

HOWARD CAMPBELL
Albuquerque, New Mexico

MATT CARTMILL REPLIES: When I wrote "109,000 hours," what I meant was 109 *million* hours. The correct figures, taken from the 1990 *U. S. Statistical Abstracts* are as follows:

Year	*Hours of Hunting on U. S.(BLM) Lands*
1982	108,996,000
1983	92,974,000
1984	73,898,000
1985	51,842,000
1986	35,570,000
1987	57,624,000
1988	55,285,000
1989	46,760,000
1990	47,053,000

When I call these the "correct" figures, I mean only that they are the ones in that particular book. In fact, they seem fishy in various ways (for example, was there really twice as much hunting on U. S. public lands in 1984 as there was in 1986?), and other published statistics conflict with these numbers and with one another. Nevertheless, most of them point to the same general conclusion: hunting has declined in popularity in recent years. According to *Statistical Abstracts,* 12 million Americans twelve years old and over went hunting in 1955. This figure supposedly rose to 17–22 million hunters in 1965 (results from two different surveys), peaked at 32.6 million in 1977, and then dropped to 18.5 million (seven years and older, hunting with firearms only) in 1990. All these numbers fluctuate too much from one survey to the next to justify putting much faith in them, but they do seem to document a recent downward trend in sport hunting. For my purposes in writing that first paragraph, that decline was the only point at issue. It goes without saying that the popularity of hunting and its ethical status are two separate questions.

Evolution in an Orchard

Some 150 years ago, a species of North American fruit fly was first tempted by an apple

by Ron Prokopy and Guy Bush

As we peered into the tree, we caught sight of her inching forward on the surface of an apple. Moving to within three feet, we saw the small, striped female fly stop momentarily when she became aware of our presence. Undaunted, she resumed her search for the perfect spot to deposit an egg. When she found a possible site, she arched her body and began to pierce the skin of the fruit with her ovipositor. If the fly found the apple flesh to her liking, she would lay a single egg. After that, she would drag her ovipositor across the fruit surface for a minute or so, clean it with her hind legs, and fly off in search of another fruit. But in this instance, as is often the case, the female would have to wait to complete her egg laying. Just as she was about to bore into the fruit, a male that had been lurking a few inches away proceeded to sneak up from behind and pounce o her to mate.



A female apple maggot fly explores a Red Delicious apple in search of a prime spot in which to insert her egg. Before ovipositing, she will p[illegible] the fruit's flesh for the presence of nutrients and the absen[illegible] of harmful chemicals.
Ron Prokopy

We witness such scenes every summ as we search out these fruit flies, known apple maggot flies, in orchards of easte North America. To the detriment of fru growers, apples are a prime factor in the flies' growth. There they develop as la vae; there they feed, mate, and lay the eggs as adults. But the close associatio between these flies and apples is relative recent. No edible apples that are infeste by the flies are native to North Americ Edible apples were brought here by th Pilgrims in the seventeenth century. Tw hundred years later, a farmer living in th Hudson River Valley of New York Sta reported that his apples were being riddle by small, white larvae. The infestatio soon spread to surrounding areas. At abo the same time, an entomologist in Illinoi Benjamin Walsh, described a small, blac fruit fly with white markings and a distin tive wing pattern, a fly that was subs quently given the name *Rhagoletis pom nella*. This was the same fly that attacke apples in the east, but in Illinois it infeste inedible thorn apples, the fruit of nativ North American hawthorn trees.

A pioneer in economic entomolog Walsh was also the first entomologist i North America to apply Darwin's theor of evolution to the study of insects, and h proceeded to develop several ideas th have a modern ring and relevance. I 1864, for example, Walsh postulated tha insects such as *R. pomonella,* which infe particular plants, might undergo heritabl changes that would predispose them t mate on their preferred host. Walsh sug gested that these host-specific population represented "phytophagic varieties," cu

"Yecch!"

–and other comments about kids' clothes that Lands' End takes seriously.

When we added kids' clothes to the Lands' End catalog some years ago, the idea was to offer a chip off the old block.

They had to be just as *well made* as our grown-up things. So, we mostly stuck to the same fabrics, construction details, even styling.

Of course, customers four feet and under have special needs. We've taken their comments to heart, reworking some of our designs or adding new items just for them. For example:

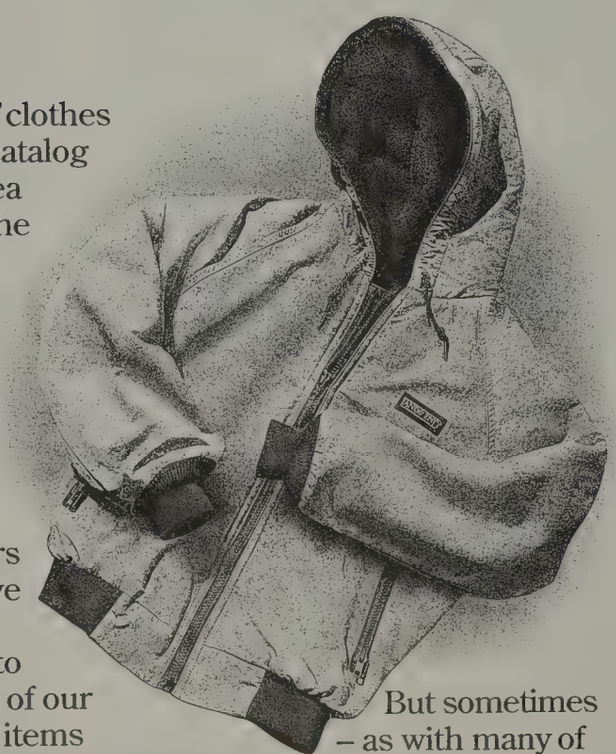
"I hate wearing hats."

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But talking with kids, we learned they hate hats (didn't *you* growing up?). Hence, our newest Squall: it has a hood.

"It's too short, Mom!"

Our kids' clothes come as close as anybody's to being indestructible: they are "hand-me-down tough."

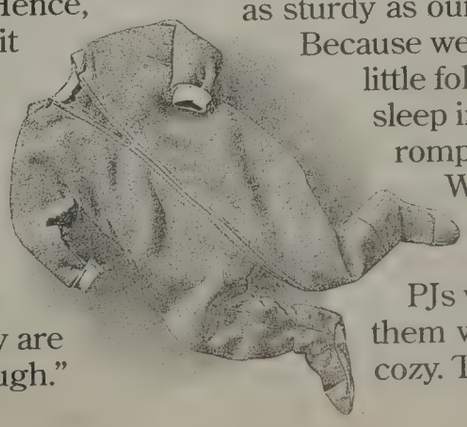


But sometimes – as with many of our snowpants – you don't *want* to hand 'em down just yet. Which is why we put "grow cuffs" on them.

Remove some stitches, and these snowpants grow a whole inch, for another inch of use.

"I'm not sleepy yet!"

We make our kids' pajamas as sturdy as our sportswear. Because we know little folks don't just sleep in PJs – they romp in 'em. When they finally *do* go to bed, our PJs will keep them warm and cozy. The fabric is exactly the same fluffy, fleecy stuff we use as lining in our adult outerwear.



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A male apple maggot fly lies in wait on the surface of a fruit. When a female, attracted by the fruit, arrives to lay an egg, he will attempt to mate with her.
Guy Bush

rently known as host races, which could eventually evolve into new species adapted to different host plants. Walsh was the first scientist to propose how new species could evolve without being isolated geographically, for example, by bodies of water or mountains. He reasoned that adherence to a new host plant could provide sufficient ecological isolation to reduce cross mating and allow host races to evolve eventually into distinct species. He believed that the population of *R. pomonella,* which originally infested native hawthorns but spread explosively onto apples in the mid-1800s, was an example of the formation of a new host race, one that had switched its allegiance from hawthorns to apples.

We have studied apple maggot flies for thirty years and have found many of Walsh's proposals to be on the mark; these flies continue to provoke thought on how new species arise. Recent studies conducted by geneticists Jeff Feder, Bruce McPheron, and others have proved what Walsh had hypothesized but could not test: that the apple and hawthorn populations of *R. pomonella* do not interbreed freely in nature. Just how this insect has come to broaden its host range from hawthorns and to form a genetically distinct host race on apples has been the subject of considerable speculation and controversy. Our long-term study of the life cycle and habits of apple maggot flies has given us clues to this process.

For an apple maggot fly, adult life begins underground on a summer morning when it pushes its way through the wall of a cocoonlike shell called a puparium. After working its way up through an inch or so of soil, it climbs onto a blade of grass or a fallen leaf to allow its wings to expand and harden. The previous summer, the fly's mother had laid one of her hundred or more eggs in a fruit produced by an overhanging tree. To survive after hatching from the egg, a larva, or maggot, must escape being parasitized by wasps, and the fruit flesh in which it resides must be sufficiently soft, nutritious, and lacking in harmful chemicals to enable it to grow to maturity. The fruit, partly rotten because of the maggot's feeding, falls to the ground while the weather is still warm enough for the mature larva to chew its way through the skin and burrow into the soil. There it manufactures the puparium in which it will spend the fall and winter before transforming into a pupa in spring and emerging as an adult in summer.

Not all adults emerge on the same day. In Massachusetts and Mic gan, for example, emergence may be s read out from June to September. Usually flies emerg beneath the same tree will do so within space of a month. Most apples ripen August and September, while hawth fruit matures in September and Octob Under apple trees, the flies' peak em gence takes place about two weeks ear than under hawthorns. Because ad apple maggot flies live only a month or a one- or two-week difference in em gence means that mating times might be synchronized. Thus at least some p portion of the flies living beneath app and hawthorns would not interbreed. R cently, Courtney Smith and his colleag at the University of Illinois found that t difference in emergence is partly under netic control. We believe that the timing emergence contributes to the process host race formation.

Apple maggot flies are ready to ta wing in search of food within a few hou after emergence. Their main sources sustenance are honeydew—the sugary e crement of sap-feeding insects such aphids and leafhoppers—and nitroge rich bird feces clinging to leaves. Duri the first week or two of their lives, wh they are still sexually immature, bo sexes are apt to roam hundreds of yards considerable distance) from their tree origin, seeking adequate food. Females, particular, search for a variety of plan since their future egg laying will be a fected by their success in foraging at th stage. A day's intake of high-quality pr tein fuels only a couple of days' worth egg laying.

Upon reaching sexual maturity, mo apple maggot flies are tens if not hundre of yards from a suitable host tree. Near twenty years ago, we began to wond how flies locate a fruiting tree, so we d signed an experiment to see if the odor host fruit served as a cue. We chose abandoned Wisconsin field that had dozen non-fruiting apple trees at lea twenty-five yards apart. Remains of fall fruit showed that several of the trees ha borne a good crop the previous yea Hence, many apple maggot flies, havi emerged that summer, were likely to be the vicinity searching for fruit.

We filled six cloth-screened containe with about half a bushel of Wealthy a ples, a cultivar favored by the apple ma got fly. The cloth masked the apples fro sight but permitted their odor to escap We put a container with apples on ever other tree and an empty container on th rest and placed sticky, odorless traps o each tree to sample fly numbers. Mo

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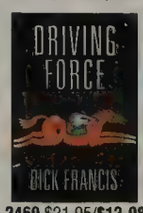
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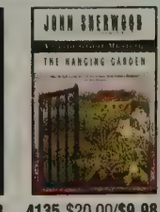
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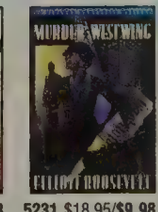
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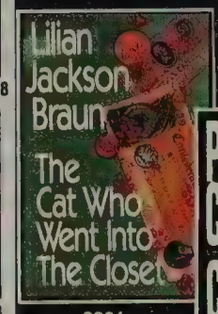
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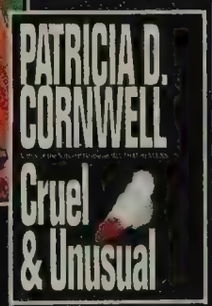
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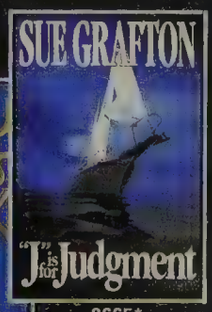
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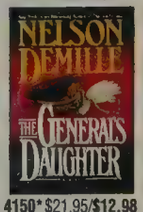
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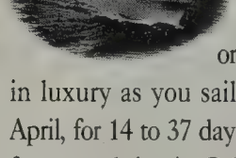
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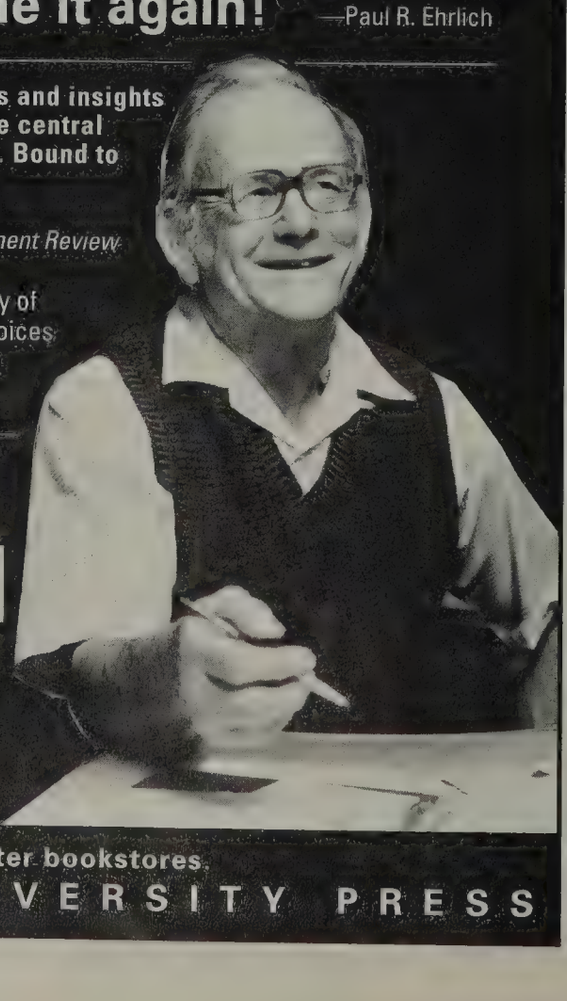
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than twice as many flies, males as well females, were captured on the trees w full containers as on those with emp containers.

This was an exciting discovery for not only because it was the first time t any *Rhagoletis* fly had been found to spond to the odor of host fruit but also cause both males and females were sponding. Subsequent research by Harv Reissig and his colleagues at Cornell U versity revealed that a suite of specific ters—aromatic compounds that produ fruit odors—given off by the fruit of so hawthorn species, and in somewhat va ant form by certain cultivars of apples, indeed attractive to both sexes. Even most aromatic fruit species or cultiv however, is not attractive throughout entire season. Not surprisingly, the peri of greatest stimulation seems to coinci with the period when fruit is most susce tible to fly egg laying and the developme of larvae.

When a mature apple maggot fly th has been hunting unsuccessfully for fruiting host tree suddenly gets a whiff the "right stuff," it must then track t odor to its source. Martin Aluja and To Green, then graduate students at the U versity of Massachusetts, enlisted oth students in a study to determine how t flies do this. The students placed emp vials, and then test vials that emitt known quantities of the synthetic equiv lent of the natural blend of attractive ho fruit esters, at varying directions and d tances from females that were released a nonfruiting potted host tree. An a emometer recorded wind speed and dire tion every few seconds. Operating pairs, the students painstakingly follow the movements of nearly 200 female When the vials were empty, femal moved within and between trees at a mo erate rate and in apparently random dire tions. The same was true when vials em ted odor but wind carried it away from th flies. When vials emitted odor and th wind blew gently toward them, howeve most flies markedly increased their acti ity and moved from tree to tree in an u wind direction. Even then flies rarely fle more than a few yards at a time befo landing on a tree, and they were reluctan to fly into any spaces devoid of trees. Th distance over which downwind flies a able to detect odor equivalent to a fe bushels of apples is at least twenty yar and may be much greater, so by engagin in bouts of short upwind flights, punct ated by frequent stops, an apple magg

follows its "nose" to an attractive host
e.

Males are probably no less adept at lo-
ing a fruiting tree, because that is where
y find mates. To illustrate this point,
me years ago in Wisconsin and Massa-
usetts, we counted fly copulations, or at-
npts at copulation, that took place on
iting host trees and on a wide variety of
ner nearby plants with and without fruit.
l forty-one attempted copulations that
saw began on fruiting host trees. Most
these matings were successful.

Once together on a tree, females and
les may mate on the foliage, but most
pulations take place right on the fruit,
ere males patrol in wait for a female.
nlike insects such as moths, female
ple maggot flies do not, as far as we
ow, produce any sort of volatile sex
eromone to attract males. Instead, the
or from host fruit serves this function
d alerts males to the possible presence
females. Electrophysiological studies
nducted by Jurg Frey at Michigan State
niversity have shown that different kinds
fruit flies respond to different suites of
it odors and that this response is geneti-
lly determined. Host-plant odor deter-
ines a fly's choice of rendezvous site for
urtship and mating and, we believe,
ays a major role in insuring reproductive
olation between different species of flies.

Observations we made some twenty
ars ago of flies on sour cherry trees in
isconsin illustrate this point. Like ap-
es, sour cherries were introduced to
orth America from abroad. About forty
ars ago, the apple maggot fly began to
rm populations on sour cherries in a
nall locale in Wisconsin. These popula-
ons proved to be only short-lived and
nce then have apparently died out. Even
rlier, however, *R. fausta,* a species not
osely related to *R. pomonella,* had per-
anently expanded its host range from na-
ve pin cherries to sour cherries. Previ-
sly, neither of these fly species had ever
en known to infest the other's native
ost. In our study, we saw many pairs of *R.*
omonella and many pairs of *R. fausta*
ating at the same time on the same tree.
Ve became intrigued, however, when we
bserved nearly as many mixed mating
airs, containing one *R. pomonella* and
ne *R. fausta*. The unrelated species were
early capable of copulating with each
ther. Recently Jeff Feder, of Michigan
tate University, studied hybridization be-
veen populations of apple maggot flies
nd blueberry maggot flies, which are
osely related. He found that while these two species mate readily in the laboratory and can produce fertile offspring when mated in hybrid crosses, they rarely if ever hybridize in nature, even when their respective host plants are growing within a few feet of each other. Our observations and Feder's subsequent work show that it is not an inability to mate or hybridize that separates closely related species and host races; rather the host plant species they frequent serve to isolate them.

We also found that at close range—within two feet or so—a fly's vision can help it find an appropriate individual fruit. In addition, prior experience may help a fly discover certain sorts of host fruit. For example, females experienced in finding and ovipositing into greenish yellow hawthorns or apples are better able to locate this color of fruit visually than are females experienced only with red fruit. So it seems that in this respect, apple maggot flies are somewhat like honey bees in their ability to learn through practice to find certain kinds of valuable resources.

Once having landed on a fruit, a female usually circles for a minute, inspecting the quality of the surface, possibly to ascertain the status of the flesh within. Using real fruit as well as wax models, we and others



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have found that mature females previously inexperienced with any fruit as adults, but which spent their larval stage in an apple, are considerably more likely to attempt to lay eggs in larger fruit than are females originating from hawthorns, a much smaller fruit. We suspect that in addition to fruit size, different fruit surface chemicals may strike a chord among flies of different host origin. Males that emerge from apples are also likely to spend more time in and around apple-sized fruit (where they will encounter females of their own host race) than are males that hatch from hawthorn fruit.

After her ovipositor has pierced the skin of a fruit, a female may or may not lay an egg. Her decision depends in part on the types and concentrations of sugars and acids she senses with the chemical receptors on her ovipositor. It may also depend on her detection of plant-produced compounds that may be harmful to the larva. One of the most intriguing of all behaviors of the apple maggot fly is the virtually invariable act of dragging the ovipositor across the fruit surface after an egg has been laid. We first noticed this long ago while observing female flies in a Wisconsin sour cherry orchard. At first we thought a female was simply trying to dry off her ovipositor after probing the fruit. But simple experiments revealed that following egg laying, a female drags her ovipositor to deposit a trail of feces that contains a subtle pheromone, which serves as a chemical marker signaling that an egg has already been laid in a fruit. Such information is of great benefit to all females, because overloading a small fruit, such as a hawthorn, with eggs is likely to result in the death of all but the first one or two larvae to hatch.

We believe that genetic changes affecting responses of both sexes to physical and chemical properties of fruit, coupled with the ability of both males and females to learn to respond to fruit stimuli, are important factors contributing to the origin of the apple race of *R. pomonella*. Mutations in key genes that influence the flies' perception of fruit odor and the timing of emergence can profoundly affect mate choice, the selection of an egg-laying site, and possibly also the temporal isolation of races. Although we do not know which genes control emergence time or determine whether an apple maggot fly will move randomly or upwind upon encountering a puff of air bearing the aroma of apples, we offer the following scenario to explain the appearance of the apple race.

About a century and a half ago, ne mutations or, more likely, the right mi ture of preexisting rare variant alleles genes combined in at least one populati of flies originating on hawthorns. The fli with these alleles were drawn not only the odor of hawthorns but also to t aroma of one or more cultivars of apple They also were genetically predisposed emerge early in the season, when more a ples than hawthorn fruits were availab and ripe for egg laying. Because bo males and females responded to the sam chemical cues, they would rendezvous o their new fruit, apples, where they mat and where the female eventually laid egg Some of the resultant viable larvae carri the variant alleles. When their turn can to reproduce, these offspring also soug apples for mating and egg laying. Thu the stage was set for the sort of restricte gene flow that we now see between pop lations of hawthorn and apple flies. An new mutations or rare existing variant all les that improved host fruit finding beha ior, larval survival, or the synchronizatio of adult emergence with the fruiting p riod of apples would be incorporated s lectively into the genetic makeup of eac host race. In time, the two evolving ho races would be less and less likely to ma with each other. Eventually, they migh evolve into two host-specific species.

We recently modeled our scenario on computer, paralleling in genetic term what Benjamin Walsh proposed long ag We are now attempting to identify the pe tinent genes and prepare a genetic map o *R. pomonella*. If we are successful, we wi be able to determine what kinds o changes occur at the molecular level i genes controlling such important traits a host selection and emergence time. Thi would provide insight into the mechanism of host-race formation and of speciation Such information could also prove usefu in future management of apple maggo flies as agricultural pests.

When we began to study these pic turesque flies some thirty years ago, w had no idea that they led such fascinatin lives. They have become, for us, a life long passion and have led us from man agement and behavioral studies into th realm of microevolution and into majo questions of how new species originate.

Ron Prokopy is a professor of entomolog at the University of Massachusetts i Amherst. Guy Bush is Hannah Professo of Evolutionary Biology at Michigan Stat University in East Lansing.



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A SWEDISH OBSESSION

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The beauty of true and false flowers has little to do with humans

by Stephen Jay Gould

Darwin rarely used the conventional rhetorical device of depicting nature as a person (invariably female in traditional usage). Darwin desisted for two good and personal reasons. First, his central theory of natural selection held that no direct causes worked at such comprehensive levels and that all general, and apparently purposive, patterns arose as a side consequence of struggle among individual organisms for reproductive success. Second, Darwin was not a lyrical writer, and he did not often resort to metaphors that might misstate the proper locus of causality. Thus, we may regard the final sentence of his book on the fertilization of orchids by insects (written in 1862 as his first full work following the *Origin of Species*) as unusual and puzzling. Darwin wrote: "It is hardly an exaggeration to say that Nature tells us, in the most emphatic manner, that she abhors perpetual self-fertilization."

I believe that Darwin was driven to this rare verbal device by his awe at the intensity of the phenomenon—at the enormous range of devices, often highly complex, evolved by flowers to assure that pollen does not always fertilize flowers on the same plant, but finds its way to the female organs of other plants, thus guaranteeing cross-fertilization. Darwin wrote: "In my examination of Orchids, hardly any fact has struck me so much as the endless diversities of structure—the prodigality of resources—for gaining the very same end, namely, the fertilization of one flower by pollen from another plant."

(Darwin did not know the genetic reasons for the biological danger of such frequent self-fertilization or of sexual reproduction between very close relatives, but his culture certainly possessed sufficient folk wisdom about frequent hereditary deficiencies in offspring of such unions—and he correctly reasoned that natural selection must therefore strongly favor mating between nonrelatives. He also recognized that the evolution of devices to prevent self-fertilization would therefore operate as a good test for the power of natural selection, for if selection could not insure this most elementary of all biological imperatives, then his favored mechanism of evolutionary change had little power and his entire theory must fail.)

Among many modes evolved by plants to assure cross-fertilization, none is so common, so interesting, so provocative in inspiring endless books on the subject, and so fundamental in structuring our planetary ecosystems as the attraction of insects (and sometimes other creatures, including hummingbirds) to a flower, the development of devices to assure that pollen will be affixed to the visitor, and the evolution of other structures to promote the transfer of this pollen to female parts of other flowers visited later by the same insects. One might even say, to a first approximation, that the most striking characteristics of flowers—their sizes, shapes, and clustering; the beauty of their colors; the sweetness of their odors—exist largely as features evolved to attract animal pollinators. We once thought, in our arrogance, that God had so fashioned flowers for our delectation, but we are only the lucky beneficiaries of an eminently practical arrangement first evolved almost a hundred million years before our appearance on this planet. Going further, most evolutionary biologists would also argue that the evolution of flowers as devices to assure cross-fertilization provides the most important reason for domination of the plant kingdom by the late-evolving group of angiosperms (or flowering plants). Thom Gray's famous lines may be good poe and fine metaphor, but they win no pri for accuracy as natural history:

> Full many a flower is born to
> blush unseen
> And waste its sweetness on the
> desert air.

Gray need not have lamented. Th flower probably passed a most useful short, existence, attracting insects and curing its Darwinian fitness by having pollen transferred!

If you have never contemplated t magnitude of this mutually beneficial lin age between insects and flowers (food the animals, fertilization for the plants) few hours with Darwin's 1862 book w provide great pleasure and reward. T full title reads: *The Various Contrivanc by Which Orchids Are Fertilized by I sects.* The book is the botanical equivale of a bestiary (do we have such a word f the plant kingdom?), cataloging the asto ishingly complex devices evolved by o chids to attract insects, attach pollen, a later to detach the bounty onto anoth flower. Among the various traps, lur and enticements, prurient humanity h found no solution more worthy of no than orchids with flowers so strikingly li the female genitalia of appropriate insec that visiting males attempt to copulate a get a dose of pollen for a reward.

When such a pervasive system com into place, on a worldwide basis in almo every environment, it becomes availab for advantageous copying by evolutiona interlopers. In other words, if an insect c be induced to transfer a small, detachab part of an organism to another member the same species, then such an organis

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might achieve great benefit if it could evolve to look like a flower and smell like a flower. This essay tells the story of a fungus that requires the mixing of two mating types at a vital stage in its life cycle, and that has achieved this end by mimicking a flower both in looks and odor, thus commandeering insects to effect the transfer. I promise to relate the story (the best part of any essay in natural history) just a few paragraphs down the road, but first some comments on the general evolutionary phenomenon of look-alikes in a world with a predominant and opposite motif of diversification into a stunning variety of unique objects.

The copycat theme finds its most evident expression in a phenomenon that evolutionary biologists call mimicry. Many animals gain protection by evolving to look like something innocuous or inedible: stick insects freeze their motion and look like dead twigs; bitterns extend their necks, compress their thin bodies, and become indistinguishable from reeds in the marsh. In the classic textbook case, a tasty animal evolves an uncanny resemblance to an unpalatable relative that potential predators have learned to avoid. Have we not all seen the grand cliché of natural history filmmaking—a bird vomiting up a poisonous monarch butterfly? In this case the story of mimicry extends to etymology itself—for the tasty viceroy is a stand-in (as in vice-president) for the true king (*roi,* or *roy* in older spellings), or monarch.

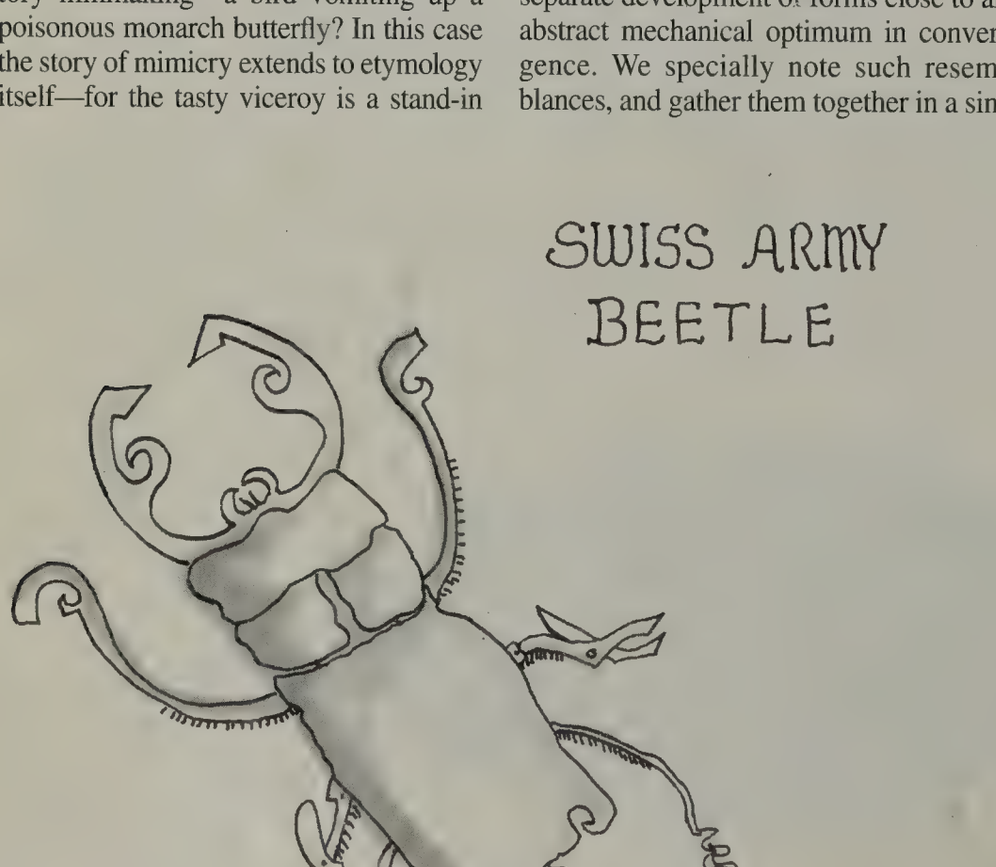
Textbooks of evolution do not generally link the phenomena, but mimicry has much in common with a wider principle known as convergence, or the separate evolution of striking similarity for functional reasons among creatures of very different ancestry. Convergence arises because functional solutions may be few, while many lineages often adapt to a similar role. Any vertebrate that flies will have to obey a stringent set of biomechanical requirements, and wings may be the only solution available within constraints of vertebrate design. Perhaps we should not be so surprised that birds, bats, and pterosaurs separately evolved wings of such striking aerodynamic similarity, based on such different anatomical underpinnings (pterosaurs extend one finger to form the leading edge of the wing, birds attach feathers to the forearm, bats extend all fingers into the wing membrane).

The conceptual similarity between mimicry and the more general phenomenon of convergence lies in their common theme of evolving such remarkable resemblance in independent lineages—the "copying" of one by another in mimicry; separate development of forms close to an abstract mechanical optimum in convergence. We specially note such resemblances, and gather them together in a single conceptual space, because any
peated evolution of strong similarity r
counter to the fundamental theme of e
lution as a constantly diversifying proc
in a world so full of innumerable possi
ities that nothing should ever happ
twice. Any form of separately evolv
similarity—by mimicry, convergence,
any other process—leads us to think t
some pathways of life's history may
predictable after all. Perhaps islan
maybe even continents, of determini
exist within the grand flow of contingen
that drives the ever-spreading river of
through time. Perhaps the sciences of h
torical change might even aspire to
predictability of Galileo's inclined pla
or Foucault's pendulum, leaving behi
the messy images of pasts that need
have been and futures that cannot
known.

Nothing like fungi to bring such rev
ies back to earth and concrete illustrati
The fungi include mushrooms, bre
molds, and a host of ubiquitous allies fr
the cause of athlete's foot to the myceli
that may be swallowing Michigan (see
column of July 1992). Fungi used to
classified as plants in the discredited a
outdated Procrustean system that forc
every multicellular organism to be eith
an animal or a plant. But fungi are now
garded as members of a separate kingd
of life, and the latest genetic eviden
points to a closer relationship with anim
than with true plants.

Many fungi have complex life cyc
featuring two mating types usually call
plus and minus, for this system bears
evident homology with the distinction
male and female in animals. The mati
types grow separate structures in o
phase of the life cycle, but must then jo
to produce a different form in anoth
phase of the cycle. In many fungi, the
sexual form is initiated by transfer of n
clei from a "donor," or "male," organ
receptors on an "acceptor," or "female
part. This system obviously resembles t
transport of pollen between flowers
plants. Moreover, since fungi infect plan
and may therefore live in proximity
flowers and their insect pollinators, t
prerequisites for convergence are
place—structural similarity in the need
transfer small bits from one fungal grow
to another, and presence in the right plac
where insects already benefit plants wi
such service. Any fungus that could mim
the floral parts or odors of plants cou
gain a great evolutionary boost.

The natural history of fungi featur



eral independent evolutions of devices promote fertilization by insects. The t fungi, for example, form a group with jor impact upon human life, both as a ult of their abundance (some thousand cies in North America) and their atks upon important crops (the stem rust *ccinia graminis* is an important parasite wheat, rye, and other grasses). Most ts form reddish or brownish patches of ores on their hosts. In 1927, J. H. aigie reported one of those serendipis discoveries so beloved by scientists d so prevalent in our lore (*Nature,* vol. 0, p. 765):

May 17, Prof. A. H. Reginald Butler uld you imagine a better name in all your llywood dreams?], of the University of nitoba, was in the greenhouse of the Donion Rust Research Laboratory inspect the experiments in progress. A solitary one of the first to appear after the winter son, had entered the greenhouse. Profes Butler directed my attention to the fact t the fly was settling on the sunflower ves, sipping nectar at the pycnia of one stule [of the rust fungus *Puccinia helnthia*] and then flying off to another leaf d sipping the nectar of the pycnia of aner pustule, and he at once said: "The soion of the problem of the function of the cnia is an entomological one."... This ggestion has been tested experimentally ring the past summer and its excellence s been amply demonstrated.

Craigie showed, in a series of clever exriments, that fungal spores of one mat type adhere to flies and then mix with ores of the other type, thus initiating the xual phase of the life cycle, when the me fly visits another patch of fungus on different leaf. He also demonstrated that e fungus patches actively encourage vis from the flies, by secreting a sugary ctar "sipped by the flies with avidity" d perhaps also by visual attraction, since e fungal pustules are "made conspicus" by their yellow or red colors. Craigie ncluded that the fungal patches "attract es and reward them for their visits in ry much the same way as do flowers."

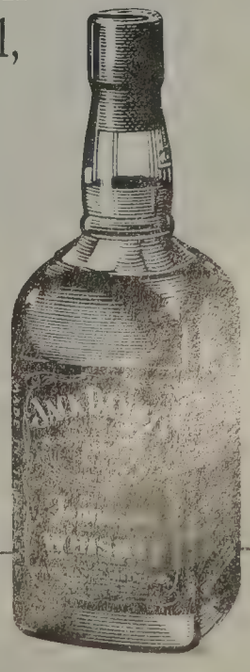
These fungal patches do not mimic flo parts in any precise visual way (alough we should not impose our prerred mode of perception on other eatures; the taste or odor mimicry of ower by fungus may well be highly deloped). Other fungi add a layer of comexity by evolving a visual resemblance; oreover, they often commandeer the ant's growth patterns for their own rposes, rather than constructing the imicry from fungal parts. In 1985, for ample, L. R. and S. W. T. Batra demon-



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strated how fungi in several species of *Monilinia* can spread among blueberries and huckleberries by using insects as vectors (*Science,* vol. 228, pp. 1011–13; *Natural History,* August 1987). The fungus first attacks leaves, and the leaves subsequently attract insects in two ways. First, "an odor resembling fermented tea is produced by infected leaves" at the fungal lesions; insects "are attracted to these wilted leaves, where they lick the mantle of conidia [the fungal structure] and become contaminated with [fungal] spores." Second, although "in daylight, the wilted leaves do not visually resemble the host's white, yellow, and pink flowers," many insects see in an ultraviolet range invisible to humans. Batra and Batra found that the ultraviolet reflectance of infected leaves, sharply contrasted with surrounding healthy leaves, seemed to attract insects (and to elicit the flight patterns of flower feeding), and also resembled the "nectar guides," or visual pathways (often in the ultraviolet range), evolved by many flowers as insect enticers.

Batra and Batra conclude that "the infected, discolored leaves evidently mimic the flowers of their host in yielding sugary rewards to the [insects] and, to some extent, in providing them with ultraviolet-reflective patterns analogous to nectar guides." (In this case, fungi do not "use" insects for fertilization, but rather as a mechanism for spreading from one plant to another. Insects carry the fungal spores from infected leaves to true flowers, and thence to other flowers.)

In another example of more overt floral parasitism, the anther-smut fungus *Ustilago violacea* sterilizes flowers of both sexes in its plant host, *Silene alba* (male flowers do not produce pollen, while ovaries of female flowers abort early in development). The fungus induces the flowers (both male and female) to produce stamens without pollen, but filled with fungal spores. Insects then transmit the spores from plant to plant. Alexander and Maltby demonstrate that infected plants tend to produce many more (if smaller) flowers than healthy plants (*Oecologia,* vol. 84, pp. 249–53). They conclude that "the fungus should benefit from the increased spore production. Additionally, the increased number of sporulating flowers may increase the chance of disease transmission through the attraction of more insect vectors."

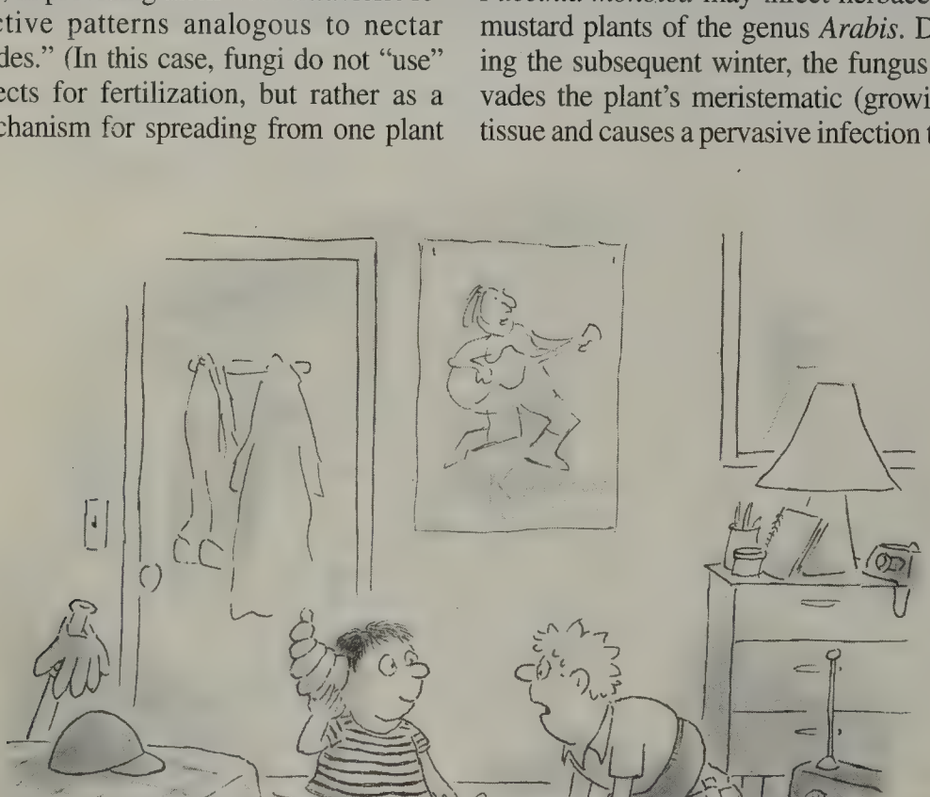
But I write this essay because a more interesting, almost fiendishly complex case has just been elucidated by B. A. Roy and published in the British journal *Nature* (March 4, 1993, pp. 56–58). In late summer, windborne spores of the rust fungus *Puccinia monoica* may infect herbaceous mustard plants of the genus *Arabis*. During the subsequent winter, the fungus invades the plant's meristematic (growing) tissue and causes a pervasive infection that radically changes the growth and form *Arabis* plants. Infected plants of *Ara holboellii,* for example, may produ twice as many leaves, twice as many le rosettes, and grow twice as tall as nonflo ering, uninfected plants.

But the remarkable part of this story e tends well beyond mere number to t color, shape, and odor of infected plants. normal *A. holboellii* plant produces flo ers by "bolting," or producing a rapid growing, elongated stem and then dev oping flowers at its end. The bolting ste either gives or receives a signal for flow ing once it reaches a crucial height. T fungus has subverted this system for own utility in a fascinating way. Infect plants do enter the bolting stage, but t central, elongating stem never reaches t crucial height that would lead to floweri (Thus, the bolted and infected plants a taller than healthy but unbolted specime although shorter than fully floweri healthy plants. Perhaps the diversion more energy to produce extra leaves a rosettes in infected plants prevents t bolting stem from reaching the cruci height needed to produce its own flower

The bolted stem of infected plants th develops a dense cluster of leaves at its u flowered end. Bright yellow fungus cove the surface of these leaves and secretes sticky, sugary fluid that insects seem love. At such a density of leaves, wi bright color and strong odor, the bolt ends of infected plants look for all t world like yellow flowers of many su rounding plants. As a most striking poi about this particular mimicry, Roy not that these fungal pseudoflowers do not r semble true flowers of their host plant, *holboellii*. Rather, they mimic the yello flowers of other neighboring plant specie particularly buttercups of the genus *R nunculus*. In other words, and strange as sounds, fungal infection induces plants grow in such a way that they mimic flow ers of *other,* co-occurring species.

The situation may sound bizarre, b from the standpoint of evolutionary a vantage to the fungus, the species chose for mimicry is immaterial so long as i sects are attracted and do their work. (A Mr. Steinbrenner once said about the ec nomics of major sporting events, it's a about "getting the fannies into the seats It doesn't matter which fannies, so long a they come, behave adequately well, an pay the appointed price.)

Perhaps the fungus is yellow for oth reasons, and buttercups become easier copy than the host's own flowers. Or pe



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THE GOLDEN EAGLE RING

haps yellow colors generally prevail in environments favored by *Arabis,* and insects might be drawn more easily to a yellow mimic. Roy suggests such an explanation in writing: "The color of pseudoflowers is indistinguishable in both the ultraviolet and visible spectra from that of yellow flowers of some co-occurring angiosperms and contrasts sharply with green vegetation. Yellow is a particularly common color for flowers of plants that, like *Arabis,* frequent high elevations, high latitudes and open habitats."

In any case, the ruse works, and insects flock to the fungal pseudoflowers (and why not; the insects are not fooled in terms of their own requirements, for they get nourishment whether the source be fungal or plant nectar). In fact, Roy shows that insects generally favor the fungal pseudoflowers to surrounding true flowers, both in initial selection and in time subsequently spent. She found, for example, that flies visiting both fungal pseudoflowers and true flowers of the genus *Pulsatilla* spent five times longer, on average, at the fungal forgeries. In mixed plots, including fungal pseudoflowers, buttercups, and true flowers of several other species, "insect visitors also spent 88 percent of their time on pseudoflowers." Roy supposes that "pseudoflowers may detain pollinators for relatively long visits because…sugar is spread over the whole surface of the pseudoflower, rather than being concentrated in a nectary."

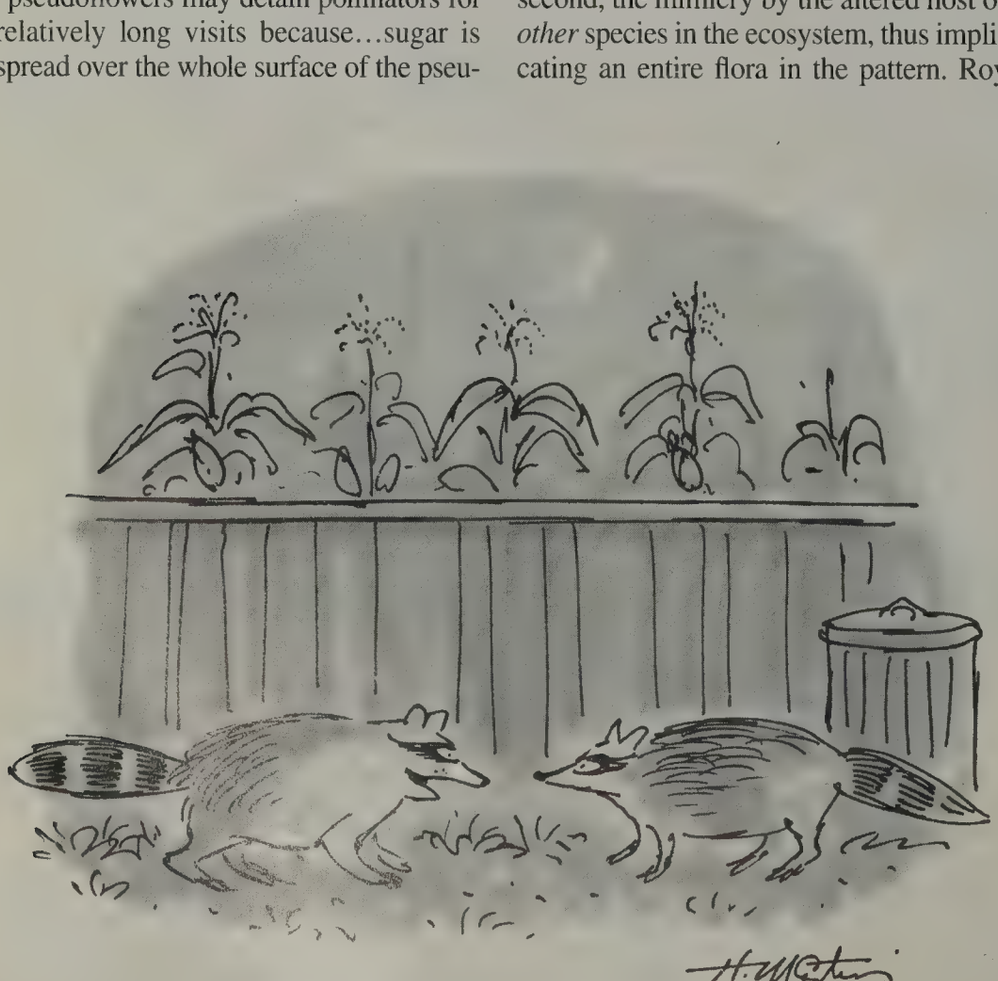
The ruse also works in another striking way—by fooling every other relevant biological agent as well, not only the insect pollinators. For example, predators of the pollinators lie in wait within the pseudoflowers (although, again, one may say that the predators are not fooled, but just properly hanging out wherever their prey may come). Roy writes: "Crab spiders and other predators of pollinators were also observed waiting for prey inside pseudoflowers, just as they do in flowers." Most intriguingly, as the only agent to whom explicit notions of trickery may be legitimately ascribed, humans fall for the deceptions just as readily. Roy notes: "The floral mimicry fools humans as well as insects: botany students at the Rocky Mountain Biological Laboratory have frequently collected pseudoflowers thinking they were flowers and, at a distance, many professional botanists have mistaken them for true flowers."

In summary, the unusual character of this mimicry resides in two stunning features: first, the production of resemblance, not so much by the beneficiary itself but by the fungus's ability to commandeer and alter the growth patterns of its plant host; second, the mimicry by the altered host of *other* species in the ecosystem, thus implicating an entire flora in the pattern. Roy summarizes her conclusions: "*Puccini monoica* does not exploit its host's flow ers; instead, it causes its host to construct completely counterfeit flower, one tha mimics flowers of co-blooming specie such as buttercups, rather than mimickin the host itself.... Thus, this plant diseas affects not only its hosts, but an entire nat ural community as well."

Stories of such precise resemblance evolved by organisms so divergent that w classify them in different kingdoms, mus inspire hopes for a natural world les capricious (and more predictable) than ou fears or our resignations often lead us t suspect. After all, if a fungus can so pre cisely mimic a flower, then certain natura forms must stand as limited and antici pated optima—to be evolved again an again by organisms in similar ecologica circumstances or pressures of natural se lection. Since the image of such a sensibl and predictable history, with humans rul ing the roost by natural right, ranks so hig among the psychological hopes and socia conventions of Western life, we may b forgiven for clutching at any natural tal that might be read as evidence for such scenario—hence, our fascination for mim icry, convergence, and all the other evolu tionary phenomena that produce adaptiv similarities rather than continual unique ness and variety.

I do not, of course, deny that the histor of life includes predictable events and re current patterns. I do, however, suspec that most predictable aspects of life lie a too "high" a level of generality to validat what really stirs and troubles our souls— the hope that we might ratify as a neces sary event the evolutionary origin of a lit tle twig called *Homo sapiens.* That is, I an perfectly willing to grant the repeatabilit of such morphological principles as bilat eral symmetry in mobile, multicellular or ganisms, or such ecological rules as "mor biomass in prey than in their predators. But similar predictability does not exten to any particular event of a unique an contingent evolutionary pathway—an I'm afraid that the evolution of *Hom sapiens* counts as a singular event, not generality.

Similarly, I fear that mimicry, whil validating a purely local predictabilit within a complex set of boundary condi tions, cannot give us what we really want—predictability *from first principle* for details at the level of our own origin The impediment to our hopes lies in th contingency of the boundary condition themselves. Sure, give me a system al



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U.S. Population Growth, Do We Really Want To Stop It?

As Mark Twain said, "Everybody talks about the weather, but nobody does anything about it." The same could be said of U.S. population growth.

Recognizing that our population growth is the root cause of the degradation of our environment, many environmental organizations are in favor of halting it, but how many are willing to actually recommend specific measures designed to **reduce fertility and immigration**?

Like it or not, **those are the only two factors that are the driving forces behind our alarming growth in numbers**. If we cannot come to grips with that reality, then we can do nothing to halt our population growth.

Are we in a crisis situation? You bet we are. The Census Bureau projects (middle series) that our present U.S. population of 257 million will grow to about 383 million by 2050, with no end to growth in sight. Many feel that even these alarming projections are far too conservative.

The impact of such numbers on our already over-stressed environmental and economic systems would be disastrous.

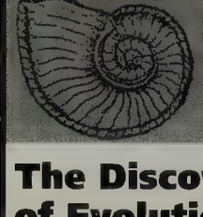
If U.S. population growth is a major problem, then **why don't we do something about it?** Are we just going to keep on sitting around doing nothing while the ship sinks under us? What a tragedy that would be!

Simply being for an end to population growth is of little or no effect. U.S. population growth will not be influenced by generalized statements that it should stop. Wishing will not make it go away.

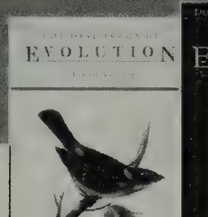
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ready in place, where plants achieve fertilization by conning insects into transporting pollen as they feed, and I will predict that any other creature with pollen-sized parts needing a boost from place to place might do well to mimic a flower and cash in upon a going concern. But if I could rerun the tape of life from the origin of unicellular organisms, what odds would you give me on the reevolution of this complex and contingent insect–flower system—the prerequisite in boundary conditions for our story of fungal mimicry? Would we see anything like either insects or flowers in the rerun? Would terrestrial life originate at all? Would we get mobile creatures that we could call animals? Would we even get macroscopic or multicellular organisms? Fine-scale predictability only arises when you are already 99 percent of the way toward a particular result—and the establishment of this 99 percent lies firmly in the domain of unrepeatable contingency. Give me *Homo erectus* and I will predict the evolution of artistic expression in some form. But give me a Cambrian trilobite as the most complex living animal and I dare not even anticipate the evolution of any vertebrate.

Historian Michael Shermer has well summarized the interaction of randomness and predictability in history in an article in *Nonlinear Science Today* (vol. 2, no. 4, 1993, pp. 1–13): "The Chaos of History: On a Chaotic Model That Represents the Role of Contingency and Necessity in Historical Sequences." He constructs and illustrates, using the fashionable concepts and terms of chaos theory, a model that he calls "contingent-necessity," or "a conjuncture of events compelling a certain course of action by constraining prior conditions." (Shermer uses the Battle of Antietam as his main illustration, as I and others have used Gettysburg for similar purposes. An American can scarcely escape the horror and fascination of the Civil War—and our understanding that the whole bloody affair need not have happened, and would never have occurred in the same way again, yet careered down an unstoppable path once a certain weight of circumstances had accumulated.)

Shermer emphasizes the unrepeatable oddities that must be strangely strung together to set the complex context and boundary conditions of any historical sequence. (At this stage, the lack of a horseshoe nail can threaten the kingdom.) But later stages of the sequence may then unroll with unstoppable predictability. (The horse went lame, the messenger never ar-

ed, the army was destroyed, and noth-
can save the kingdom now. A jester ar-
es on the field of war holding a horse-
oe nail—and no more ridiculous
mple of "too little, too late" could ever
given.) Shermer summarizes the shift
m pervasive early contingency to
ctly local (and late) necessity: "In the
velopment of any historical sequence
role of contingencies in the construc-
n of necessities is accentuated in the
ly stages and attenuated in the later."
ngal pseudoflowers are late necessities,
l they give us no reason to suppose that
complex contingent prerequisite for
s sensible story—the evolution of the
ect–flower system—has any similar
dictability.

As an interesting consequence of Sher-
r's model, we may ask why life as a
ole doesn't finally settle down to glob-
y predictable unrolling, whatever the
ssive contingency of initial stages.
ermer points, correctly I think, to the
portance of infrequent and highly dis-
bing events [such as mass extinction for
nas or punctuated equilibria for lin-
ges] in derailing the stasis or predictable
rolling of systems otherwise stabilized.
e theoretical importance of rare, and
netimes cataclysmic, events—as the
servers and reinvigorators of global
ntingency—may best be appreciated in
light of such historical models.)

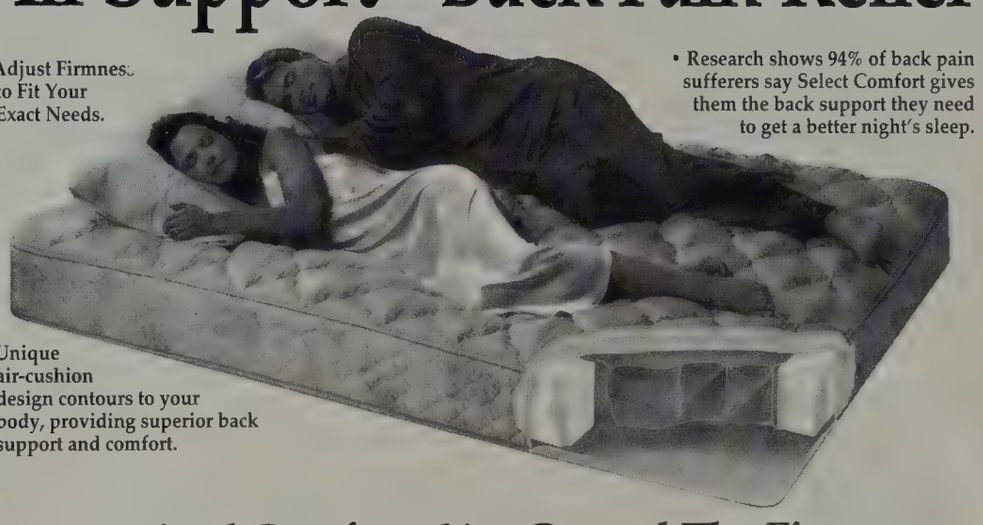
Darwin was also interested in the com-
x interaction of randomness and pre-
tability, although I think that he empha-
ed repeatability unduly in this seminal
ssage on the eventual reestablishment of
nt communities in cleared fields (in this
e, on former Indian mounds):

nen we look at the plants and bushes
thing an entangled bank, we are tempted
attribute their proportional numbers and
ds to what we call chance. But how false
view is this! Everyone has heard that
en an American forest is cut down, a
y different vegetation springs up; but it
s been observed that the trees now grow-
on the ancient Indian mounds in the
uthern United States display the same
autiful diversity and proportion of kinds
in the surrounding virgin forests....
row up a handful of feathers, and all must
l to the ground according to definite laws;
t how simple is this problem compared to
action and reaction of the innumerable
nts and animals which have determined,
the course of centuries, the proportional
mbers and kinds of trees now growing on
old Indian ruins!

I certainly share Darwin's awe at the
stablishment of the "same beautiful di-
rsity" with the same "proportion of kinds" in the reconstituted forest. This repetition indicates some predictability and some lawlike structuring in the forest ecosystem. But we may not draw any implications from this story about broader necessity for life's particular pathways. Climax forests are in the stable phase, the last predictable part, of one of Shermer's sequences. We can anticipate what will eventually grow on the Indian mounds, for this system *already exists* in the neighboring forest—just as fungal pseudoflowers make predictable sense because they have horned-in upon the long and well-constructed system of insect–flower interactions. But a replay of life's tape would probably not yield a forest ecosystem at all—perhaps neither an ecosystem nor a forest nor life in any familiar form. The replay might provide no trees and almost certainly no Indian mounds to form a cleared space for a regrown forest. No mounds, no communities, no people, no interactions, no hi-ho Silver, no William Tell overture, no apples or arrows, no Rossini, no Toscanini, no you and no me.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

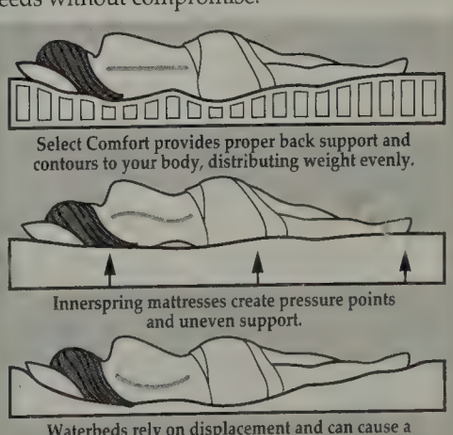
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Ouachita Mountains, Arkansas

by Robert H. Mohlenbrock

Largely contained in Ouachita National Forest, the Ouachita Mountains extend more than 200 miles across western Arkansas and southeastern Oklahoma. To the north, the broad Arkansas Valley separates them from the Ozark Plateau, while to the southeast lies the Gulf Coastal Plain. Fifty to sixty miles wide, the range consists mainly of narrow, steep-sloped ridges that run east to west, separated by valleys or basins. Spring-fed streams run parallel to the ridges or occasionally cut across them, forming spectacular ravines with picturesque waterfalls. The highest crest, between 2,850 and 2,900 feet, belongs to Rich Mountain, near the Arkansas–Oklahoma state line.

The Ouachitas are almost entirely composed of sedimentary rock—sandstone, shale, chert, limestone, and conglomerate. Geologists have a field day in the mountains because of all the folding, faulting, overturning, and compression of the strata. Botanists also have a field day with the variety of plant communities and the more than a dozen endemic species, that is, plants found in no other place in the world. The Ouachitas are the largest east–west range of mountains in the United States, and the plant communities on its north-facing slopes are distinct from those that face south (for most U.S. mountain ranges, in which the ridges run north–south, the contrast is between east- and west-facing habitats).

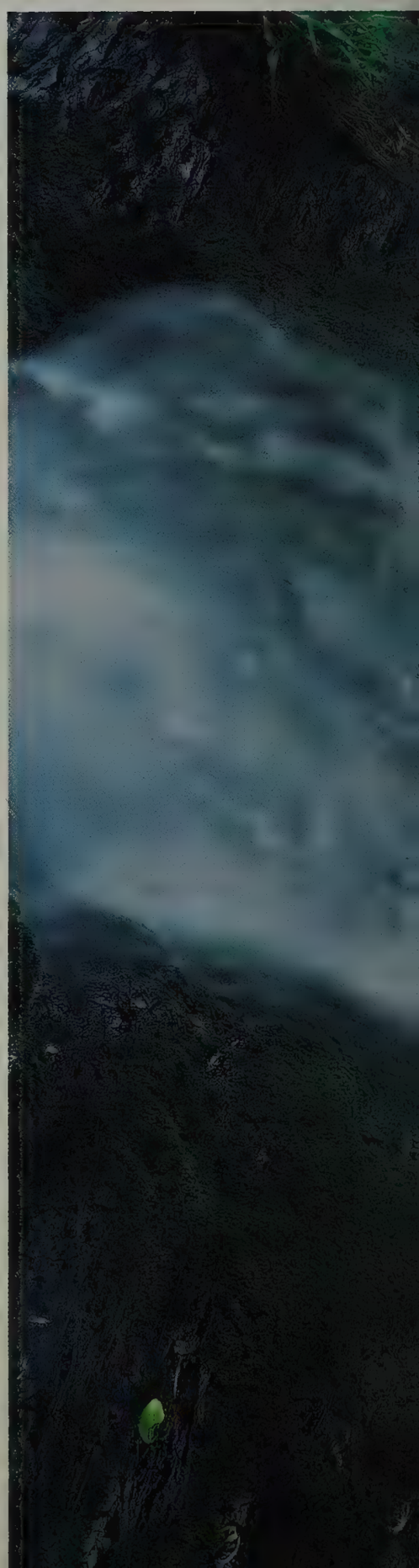


Fulton Branch Glade
Brent Wallace

Dominating the warmer, south-facing slopes are forests of southern red oak, blackjack oak, shortleaf pine, and mockernut hickory, with an abundance of smaller trees and shrubs, including persimmon, flowering dogwood, redbud, and sassafras. Cooler, north-facing slopes are inhabited by white oak and shagbark hickory, often joined by basswood and cucumber magnolia. Dense, junglelike vegetation grows beneath the trees. On the driest ridgetops, forests of stunted oaks and hickories are usually found, sometimes with mature trees only three or four feet tall.

Viewed from the numerous roads that pass by and through the Ouachita Mountains, the pine-oak forests seem monotonous. But if one hikes into the mountains, small habitats with special plant communities and endemic plants become apparent. Many owe their existence to the geological forces that have molded the landforms and exposed different types of rock. Rare plants are mostly concentrated where the underlying rock is Arkansas novaculite, an often whitish, fine-grained, gritty material high in silica. Novaculite is brittle, breaking down into large blocks that eventually fragment into smaller particles. The Indians who occupied the Ouachitas used it for making many of their stone implements.

Another rock that is home to rare plants is Mazarn shale, whose black or green layers are sometimes interleaved with layers of sandstone and limestone. Sandstone overhangs, known as rock-shelters, are common in the Ouachitas, and there are several rock-strewn openings, or glades, including novaculite glades and Mazarn-shale glades.



A waterfall takes a double plunge down Missouri Mountain in Ouachita National Forest.
Laurence Parent





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I spent a day a few miles west of Hot Springs examining two of the special plant communities in the Ouachitas. One, a little less than an acre in size, was a soggy, nearly boglike habitat adjacent to Meyers Creek. It is fed by groundwater that seeps from the flanks of the surrounding rock strata and drains across the terraces into the creek. I did not attempt to enter the seep, since it is easy to sink in above the knees. But I observed many of the wetland plants by curling my arm around tree trunks and leaning out as far as I could, or by edging my way out along strategically positioned logs.

A few trees, including sycamore, green ash, and sweet gum, have established a foothold in the seep and provide dense shade for the understory. Shrubs include swamp azalea, streamside alder, and spicebush. Many kinds of wetland grasses and sedges grow in the seep, several of them rare for this part of the country. Wildflowers include grass-leaved lily, yellow bellwort, water horehound, and blue lobelia. Royal fern, lady fern, and sphagnum moss also abound.

Immediately bordering the seep is a drier woods with umbrella magnolias, witch hazels, and American hollies. Beneath these trees grows a rich assortment of wildflowers and ferns, including crane-fly orchid, blue-leaved goldenrod, heart-leaved aster, broad beech fern, and Christmas fern. Partridgeberry, an evergreen with nearly circular leaves that is popular in terraria, creeps over much of the ground.

A few miles to the west, on a wooded south-facing slope overlooking the Ouachita River, lies Fulton Branch Glade. Surrounded by a dry forest of willow oaks, water oaks, black hickories, and shortleaf pines, the glade has only a sparse tree cover of red cedar, blackjack oak, post oak, winged elm, dwarf hackberry, and one-flowered hawthorn. Most of the trees are eerily draped with long, gray-green lichens. Beneath these trees, much of the ground consists of exposed Mazarn shale.

Because the terrain is rocky and subject to direct sunlight, moisture is limited. Among the plants that can survive the summers here are prickly pear cactus and succulents such as pink sedum, American agave, and flower-of-an-hour. More surprising, because of their rarity in this part of the Southeast, are wild hyacinth, green milkweed, black quillwort, Barbara's buttons, Engelmann's milk vetch, slender spiderwort, and two endemics—Arkansas cabbage (a large-leaved plant in the mustard family) and Hubricht's bluestar. This arid habitat stands in stark contrast to the wetland community of Meyers Creek Seep.

Robert H. Mohlenbrock, professor emeritus of plant biology at Southern Illinois University, Carbondale, explores the biological and geological highlights of the 156 U.S. national forests.

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For Immediate Release

Why do human males have certain skills?

by Roger L. Welsch

Remember when Miss Grohny made you dissect that earthworm in Biology I? You thought that you were learning about reproductive organs or nervous systems or something like that. Now that you're older, you can be told: The title on Miss Grohny's lesson plan that day was, "Show the little nippers that science ain't always pretty."

Which is my way of warning you that this column is not for the faint of heart. Some of my friends tell me that they occasionally receive brown envelopes in the mail, inside of which are more envelopes inside of envelopes, carrying warnings that if you don't want to read what's inside, then you should stop opening envelopes. Well, sometimes science is like that too, so here it is—WARNING: Enclosed are explicit science materials meant for adult eyes only!

Not long ago, a fellow scientist passed along to me a fascinating news item (FOR IMMEDIATE RELEASE!!) from the American Anthropological Association. I was taken aback because, for one thing, I didn't know that the AAA sent out press releases. But you can be sure I'm going to pay a lot more attention from now on.

The tantalizing item summarizes a research project conducted at the Institute of Human Origins. As usual, the heavy-duty science is preceded by a lot of stuff we already know—men snore more than women; people in general snore mostly while they are sleeping. Then comes the good part—the science part. Male snoring, it is speculated, is not random noise but a clever defense system: "[For our early human ancestors] sleep proved to be one of the most vulnerable times of the day. By mimicking the sound of their most common predators, carnivorous cats and hyenas, early humans could broadcast throughout the night, 'We are carnivores, we are many, we are strong, and we are healthy!' "

Boy, are they off base. My wife, Lovely Linda, assures me that my snoring says something, all right, but to her ear it announces clearly, "I am dead to the world! I sure could use some work on my adenoids! I shouldn't have had that second helping of garlic bread!" (While not disputing this interpretation, a supportive acquaintance—male, married—defended my snoring's survival functions. His theory: Men snore so women will stay awake and keep watch.)

At any rate, the trouble with anthropologists is that they like to think of themselves as scientists, but all too often they forget to apply the Scientific Method to their investigations and thus reach premature conclusions. Good thing I'm here to straighten them out.

First, let's look at the biology of the matter. Linda tells me I snore, and it may



"And Bernie here makes book on when the big one will hit."

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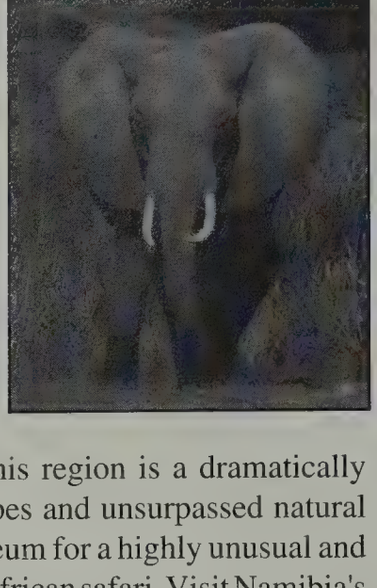
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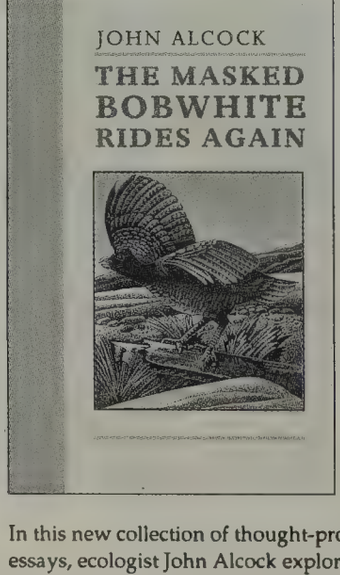


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be true, for sometimes I actually wake myself up with my own snoring, as physically impossible as that may seem. It probably is hereditary: my father says he sometimes snores so loudly he has to get up and move to the other bedroom to get some sleep.

Anyway, let's grant that I am male, that I have all the physiological devices necessary for snoring, and that I do snore. Does that mean one needs equipment like mine—a nose half the size of the rest of my head—to snore? Not at all. Lovely Linda has a little bitty nose. It's a beautiful nose, in part because it is little. While she is exceedingly sensitive about the issue, and I would appreciate it if you would keep this under your hat, she does snore. Vigorously. With grace notes and glissandos. That she is a woman and has a little nose has nothing to do with her ability to fill the night with sound.

My black Lab, Spot, has a nose the shape and size of Delaware. When he snores, he loosens shingles on our house. And the neighbors' houses. Hey, wait a minute! Isn't he one of those carnivores my snoring is supposed to threaten? Well, it doesn't. In fact, Spot couldn't care less about my snoring. Ergo: Snoring is a talent not specific to men or, for that matter, human beings.

I took my scientific musings up to Slick's Tavern last night to bounce them off the heads (not as much a metaphor as you might imagine) of my buddies. They concur with my position and dismiss the theories expressed in the news release as pure piffle. With that confirmation I could have gone home and snored away the night, but Slick tossed a scholarly hand grenade onto the seminar table, and this is where things got scientifically untidy. (Remember Miss Grohny's earthworm!) I will do what I can to handle this matter with sensitivity.

Slick said, "Well, yeah, but what about some other bodily sounds, like…er… uh…[flatulence]?"

Whoa! We ordered another round of beers and pickled hard-boiled eggs and allowed our mental and gastral gears to grind away at a problem far more complex than I or, I suspect, the Institute of Human Origins ever anticipated. Woodrow noted that dogs don't have the equipment for, that is, they don't…well, you know. But, he conceded, canines are famous for SBDs (silent but deadly). Slick then brought the discussion back on course: "My friends, here we are talking audio, not nosio." Lunchbox then threw the debate into chaos with his observation, "And

ɔmen do have the equipment but never
u-know-what, ever."
Slick tried to break Lunchbox's the-
—"Little girls do," but Lunchbox beat
ck the challenge. "Vestigially, perhaps,
t the capability is lost when the female
ild approaches maturity. And then
ere's belching. Dogs never belch."
And if ever there was an expert on
lching, it was Lunchbox. I thought I had
en around when I was in college and had
raternity brother who could belch on de-
and. That modest talent was blown
vay, so to speak, the first time I heard
unchbox belch "Budweiser," just as clear
could be. If there was any question, he
d it again. On that occasion I expressed
y admiration, whereupon he downed the
ntents of his glass and belched, "Old
ilwaukee...Lite...." I gasped. "In recy-
able aluminum cans...." I staggered.
On ice." I'll never forget it.
So, while the case for snoring was
urry at best, some biological functions at
ther end of the alimentary canal seemed
be specific to humans, and especially to
ales. Now, perhaps, we were prepared to
dulge in some speculation! Why did
uman males, and only human males,
ve certain skills? Were they survival
ols? The brain trust at Slick's Tavern of-
red its suggestions.
Back home, however, peer review was
eptical. Lovely Linda felt fairly strongly
at the two somatic resonances in ques-
on (1) had nothing to do with courtship,
though she did accept the possibility that
ey (2) might be male defense mecha-
sms. (Or, as she put it in both cases,
God knows!")
A further application of Scientific
ethod is clearly called for. When do men
lch and...the other thing? Men do these
ings most of all, best of all, when they
e in packs, leaning up against pickup
ucks, laughing and hoo-ha-ing in the
mpany of other males. One might spec-
ate that this "trumpeting" is therefore a
ale device used while jousting for pack
ominance. But I have never been with a
unch of males doing those things when
ere has been even the slightest mood of
allenge, positioning, or competition. If
ything, at these moments there is a sense
community and camaraderie. As if we
ere pursuing some cooperative ef-
rt...like hunting!
I would like to put on the anthropologi-
l table therefore the possibility that these
ale noises, considered rude in some cir-
es today, may be Pleistocene memories
hunting calls. Since the sounds are clearly not analogous to any modern game animals, we can further surmise that they echo the mating calls of extinct creatures. If I can really go out on a scientific limb here, I would like to suggest that these may be the long-lost sounds of the ultimate Stone Age hunter's prey—the woolly mammoth. (The connection may seem strained, but when I recently asked researchers at the Smithsonian Institution, "Who invented the Whoopee Cushion?" their response was, "That device's origins are lost in the mists of the past." Boy, does that tell the story or what?)

Despite my belittling of the anthropological establishment, I offer it my profound gratitude. The AAA news release has opened an entirely new field of scientific inquiry to me. What can we make of hiccups? Sneezes? Root beer coming out our collective nose? These lines of research are obviously not as attractive as, say, sequencing the human genome or analyzing the English ballad, but who can honestly say that this new direction will reveal any less about us, our origins and our ways?

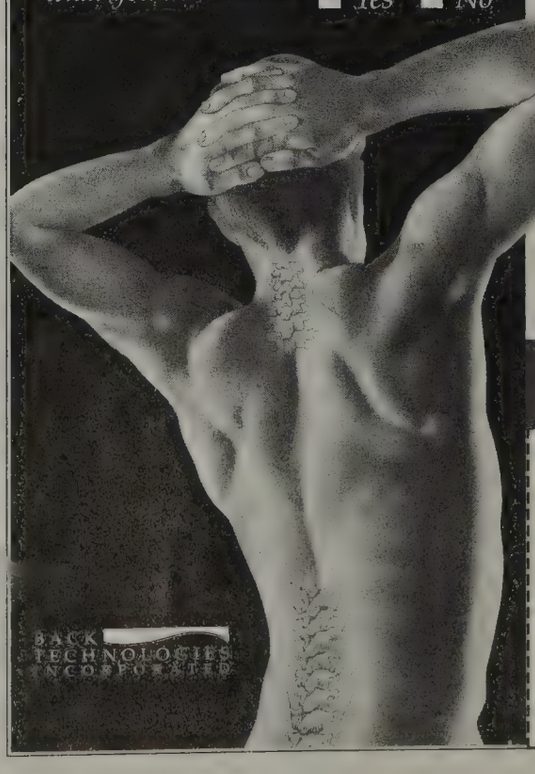
Folklorist Roger L. Welsch lives on a tree farm in Dannebrog, Nebraska.

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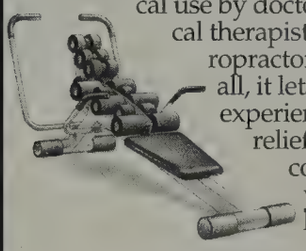
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Forewings that differ in length by just a fraction of a millimeter may keep a male scorpion fly from finding a mate.
Stephen Dalton; Oxford Scientific Films

The Allure of Symmetry

In a bilateral world, females prefer well-balanced males

by Randy Thornhill

In the summer of 1991, I traveled to Japan to study the mating success of male common Japanese scorpion flies. To conduct this study, I needed to be able to tell one individual from another, which, as every entomologist knows, can be a frustrating business, especially when the insects are on the move or interacting with one another. About three-quarters of an inch long from head to abdominal tip, this species of scorpion fly is easy to spot, but I was still pleased to discover that at my study site—in a woods on the campus of Aichi Prefecture University of Music and Arts in Nagoya—nature had provided me with a natural marking system. About 90 percent of the scorpion flies had mites attached to their bodies, and since the mites stayed put, their placement on a scorpion fly's body served as a signature of sorts.

One afternoon, I watched two adult males of this species (*Panorpa japonica*) fight over a large, dead caterpillar that I had placed on a leaf of a low-growing plant in the forest. Scorpion flies get their name from their enlarged male genitalia, which curve back over the abdomen like a scorpion's stinger. Males sometimes fight by butting against one another, but more often they use their genitalia, which end in a pair of strong, pinching claspers, as weapons. Injuries are common. When one of the males (which I named, somewhat unpoetically, Dorsal-Neck-Mite) won the fight, and thus the caterpillar, he immediately everted a large gland from his genital apparatus and began emitting pheromones attractive to females of his species. A few minutes later, the defeated male (known to me as Left-Lateral-3-Abdomen-Mite) also everted his pheromone gland and began signaling from about one foot away. The drama continued as a third male arrived and defeated the previous winner, which moved eight inches away from the caterpillar prize and began signaling again. Soon, a female appeared on the scene and proceeded to mate with the victor for almost an hour, all the while feeding on her nuptial gift—the much-contested dead caterpillar.

I observed many such scenes that summer, for scorpion flies are scavengers, and fights over their preferred food—arthropods that have died on low-growing plants—are common. In most cases, the loser of the fight did not simply fly away or stand idly by. Defeated males often positioned themselves near the victor, started releasing pheromones, and attempted to intercept females as they arrived. These "satellite" males had only limited success, however: of the 288 matings I saw, only 12, or 4 percent, involved satellites. And what little success they had was obtained by force, the males grabbing females with their genital claspers. Females managed to steer clear of the satellites most of the time, and when they were caught, they were generally able to break free before copulation began. When copulation with a satellite did take place, resistance by the female kept it short. After any interaction with a satellite, females went on to mate with the male holding the caterpillar.

What makes one scorpion fly a winner of fights and mates, and another a loser? Among the factors to be considered is body size. Like many behavioral ecologists, I always test for any relationship between an insect's body size and its performance. My findings—that the larger



Whit Bronaugh

With its genitalia curved back over its abdomen like a scorpion's stinger, a male common Japanese scorpion fly, below, presents a more formidable image than its scavenging life style warrants. Right: A male dung beetle's protruding, hornlike appendages demonstrate the sort of bilateral symmetry found in many organisms.

Hiroshi Ogawa; Nature Production





insects did not necessarily mate more often—surprised me at first because studies of other species of scorpion flies indicated that body size was correlated with success in both fighting and mating.

Closer inspection of the Japanese scorpion flies, however, revealed some intriguing physical differences between winners and losers in the contest for mates. Like many creatures, scorpion flies are bilaterally symmetrical, with three legs and two membranous wings on each side of the body. But as with all basically symmetrical organisms, from flatworms to people, sometimes things don't come out just right. My measurements showed, for example, that a scorpion fly's right and left forewings sometimes differed significantly in length. Furthermore, this difference was correlated with both fighting and mating success. Of the three scorpion flies in the fight detailed above, the insect with the most asymmetrical forewings (differing in length by 0.7 millimeters) lost the first fight. Its vanquisher, with forewings differing by 0.3 millimeters, then was defeated by the third scorpion fly, whose wings showed no detectable difference in length and which went on to mate with the female. This sort of pattern was repeated again and again.

Why should symmetry be such an apparently important measure of mating and fighting performance in scorpion flies? Some kinds of asymmetry, after all, are normal and adaptive: the large signaling claw of the fiddler crab, the laterally twisted bill of the wrybill plover, and the asymmetrically placed ears of the barn owl are just a few examples. But for organisms that have evolved bilaterally symmetrical body traits, asymmetry may be an



indication that something has gone awry. And generally the problem happens early in life.

Scorpion flies are a case in point. The caterpillarlike larvae live in leaf litter, feeding on dead insects and other organic matter. Early in the larval stage, wing buds develop internally. Once larval development (which may last about two months) is complete, the insect pupates. By the time the adult emerges, some two and a half months later, its wings have reached their full size. During their long developmental period, wings are vulnerable to a variety of environmental perturbations.

Symmetry is a delicate thing for any developing organism to pull off and, as studies of insects, fish, and birds have demonstrated, can be thrown off track by any number of disturbances, such as disease, pollutants, unusually high or low temperatures, and food deprivation. For example, numerous studies have shown that unusually high or low temperatures during larval development lead to asymmetrical adults in *Drosophila* fruit flies. Among scorpion flies, then, the degree of wing symmetry is an indication of the extent to which an individual has escaped a multitude of environmental insults during development.

The most symmetrical males won the majority of the contests over food and garnered the greatest number of matings, but just what, I wondered, was the source of their attractiveness? Drawn to the scene by male pheromones, did the female then gravitate toward whichever male had a nuptial gift to offer her or was there something about the winning male himself that was irresistible?

I designed an experiment to find out. Into each end of a 3.5-inch-diameter cylinder, I placed a tight-fitting plastic cage. I cut holes in both ends of each cage and covered them with screen to allow air in. The inner end of each little cage was covered with several layers of fine mesh. For each trial, I placed one female in the middle of the cylinder (she was introduced through a door cut into the plastic) and one pheromone-releasing male in each cage. The males differed in the degree of



ıhen Dalton; NHPA

e degree of symmetry in the long outer tail feathers of an adult ıle barn swallow reflects how successfully the bird resisted rasites when it was a nestling. These tail feathers may play at ıst as important a role in attracting a mate as in flying.

ıkichi Kameda; Nature Production



rewing symmetry. The female could not uch or even see the males through the esh; she could only smell them. Whenver a female stationed herself on the esh of a male's cage, I recorded that as a ositive attraction. I ran fifty trials, each ith a different combination of males and males. The results astonished me: in rty-four out of the fifty trials, the females sponded to the more symmetrical male. ne females even discriminated between e pheromones of males with very small fferences in wing asymmetry. Male ody size, however, was unrelated to the tractiveness of its pheromones.

What makes the pheromones of symetrical males so appealing is not yet nown. I suspect part of the explanation es in their diet. A male that has succeeded in securing a nutritious caterpillar oesn't hand it over to a female right way; he first feeds on it himself. Research n a variety of insects has demonstrated at male pheromones often derive from e diet; if this is the case with scorpion es, then eating well may enable symmetcal males to produce more, or better, neromones.

Perhaps symmetrical males are simply ore fit overall and thus intrinsically suerior at producing pheromones. If they are, and if this superiority is heritable, females that mate with them will tend to produce fit offspring; any sons would share their fathers' powers of attraction. Such a "promise" of reproductive success for her offspring would be a strong inducement to any female looking for a mate.

But is symmetry an indication of overall fitness? To find out, I designed an experiment to test the relation between symmetry and survival in Japanese scorpion flies of both sexes. After measuring forewing symmetry and marking each insect with a marker pen (this particular population carried no mites), I placed twenty males and twenty females in a large, outdoor, seminatural enclosure and provided them with food (assorted dead arthropods). Since these scorpion flies are large and conspicuous, I could safely assume that any individual not visible within the enclosure was dead. The study ran for ten days, during which time I visited the enclosure daily. The results demonstrated that symmetry was indeed positively correlated with increased survival for both males and females. Symmetrical scorpion flies appear, then, to be favored by the forces of both sexual and natural selection.

Additional evidence of the importance of symmetry came from work that I have done, together with biologist Peter Sauer, of Bielefeld University in Germany, on the German scorpion fly (*Panorpa vulgaris*). Male German scorpion flies give females nuptial gifts of hardened masses of saliva. In order to fuel their specialized salivary glands, the males must eat well. Sauer and I caught a number of males in the field and then recorded in the laboratory which ones were able to secrete saliva immediately after collection and had therefore presumably successfully competed for food in the wild. These males, which we called "fit," had more nearly symmetrical forewings than the "unfit" males that could not secrete saliva. (The unfit males were able to secrete saliva after receiving food in the laboratory.)

The German scorpion flies also provided us with an opportunity to look into the heritability of symmetry. Sauer and I bred the scorpion flies in the lab. For this study, we wanted to keep the mothers' genetic contribution uniform, so we mated both fit and unfit fathers with a group of female siblings. We also made sure food availability and other physical conditions were equal. To our satisfaction, the sons of fit males proved more successful at winning both fights for food and access to females. Furthermore, both sons and daughters of fit fathers had more symmetrical forewings than did the sons and daughters of unfit fathers.

The degree to which an individual scorpion fly develops symmetrically, then, has a genetic component that is transmitted from parent to offspring. This raises the question of how genetic variation in symmetry is maintained in natural populations. Why haven't natural and sexual selection eliminated all the "bad" genes that can lead to asymmetry? I believe that a partial explanation may lie with the effect of parasites and pathogens on developing scorpion flies. The coevolutionary race for survival between disease organisms and their hosts is a never-ending one, generating more-or-less continuous genetic variation. Due to their faster generation time, disease organisms generally have the upper hand in this race, able to adapt

Jeff Sedlik

Superb athletes tend to show particularly striking body symmetry, below. Dizzy Gillespie, right, undoubtedly owed his impressive, symmetrical cheeks as much to years of blowing the trumpet as to genes.

Richard Mackson; Sports Illustrated; Time Inc.



rapidly to whatever defenses their hosts may evolve. The more slowly evolving hosts are at a disadvantage, but since individuals differ genetically, some will be worse off than others.

Some scorpion fly larvae, for example, may find themselves with an outmoded response to the disease organisms that plague them. Less able to resist disease, these larvae may be more likely to develop asymmetrically. Others may be better equipped genetically to deal with disease, developing smoothly into symmetrical adults. Due to the continuing and rapid evolution of the pathogens, however, there is no guarantee that the offspring, or grandoffspring, of these adults will be so lucky. I believe the commonness of asymmetry arises from the inability of organisms to adapt perfectly and once-and-for-all to the rapidly evolving parasites and pathogens that afflict them.

There is considerable evidence in support of the idea that disease organisms may generate asymmetry. One study showed a correlation between an increase in asymmetry in human teeth and an increase in disease organisms. Michal Polak, of Arizona State University, has shown that *Drosophila* larvae infected with parasitic nematodes develop into asymmetrical adults. Research on barn swallows has provided perhaps the best evidence to date. Anders Møller, of Uppsala University in Sweden, has demonstrated that the presence of an important parasite on nestlings leads to striking asymmetry in the tail feathers of adult males. Like peafowl, female barn swallows are known to prefer males with symmetrical tails, apparently recognizing them as indicators of resistance to parasites.

Many studies reveal that health is a desirable trait in human mate selection as well. And since symmetry can be a measure of developmental health from before birth through adulthood, it might be expected to influence who is, and who is not, considered attractive by the opposite sex. To see whether symmetry played a role in the perception of human beauty, ethologist Karl Grammer, of Vienna University, and I conducted a study in which men and women were presented with digitalized images of opposite-sex faces of varying degrees of symmetry. We then asked these men and women to "rate" the faces in terms of sexual attractiveness. The results were that both men and women gave the most symmetrical faces the highest ratings. In a separate study at the University of New Mexico, psychologists Steve Gangested and Ron Yeo and I learned that people judged to be facially attractive also have greater overall body symmetry (both hands the same width, for example). There seems little question that for many creatures, from humans to scorpion flies, symmetry is a key ingredient in the mysterious mix we call beauty. □



New Limb on the Avian Famil

Where does a wingless, clawed bird from Mongolia fit in?

by Mark Norell, Luis Chiappe, and James Clark

For the last four summers, field parties from the American Museum of Natural History have traveled to the badlands of southern Mongolia looking for fossils from the age of dinosaurs. These expeditions continue a tradition of Museum exploration in Mongolia that started in the 1920s. Led by Museum paleontologists Roy Chapman Andrews and Walter Granger, the Central Asiatic Expeditions discovered some of the world's greatest dinosaur localities, including the Flaming Cliffs (so named because of their brilliant red color), where the first dinosaur eggs were found.

As members of the American Museum's recent joint expeditions with the Mongolian Academy of Sciences, we have revisited some of the classic localities, prospected some others discovered by Soviet, Mongolian, and Polish teams, and found a few new sites of our own. All the members of the current expedition have their own reasons for wanting to explore the rich fossil beds of the Gobi Desert. One of our main motivations was the possibility of finding dinosaur fossils that would shed light on the origin of birds.

When the first 145-million-year-old fossils of *Archaeopteryx* were unearthed more than a hundred years ago in Bavarian stone quarries, they were immediately hailed as the link between reptiles and birds. Although *Archaeopteryx* had teeth and a long reptilelike tail, it also had wings and feathers and was probably able to fly. But new discoveries and theories have recently rekindled the debate over just how birds evolved. Birds are now considered to be a subgroup of dinosaurs, descended from fast-moving, bipedal carnivores that *Archaeopteryx* greatly resembled. But we know few specifics about the transition from typical dinosaurs to birds and about early bird diversification. This is largely due to the lack of well-preserved fossils. Skeletal lightness is the key to flight, but thin, hollow bones also break quickly after a bird dies and are preserved as fossils only under extraordinary circumstances.

The few known specimens have been preserved through chance—some birds happened to perish in an environment conducive to preservation. *Archaeopteryx* and two recently discovered sparrow-sized, early Cretaceous fossil birds, *Iberomesornis* from Spain and *Sinornis* from China, were found in fine-grained, thin-bedded deposits that were once ancient lagoons or lakes. Fossils created in these conditions can be spectacular. Many even reveal delicate feather impressions. Yet other important physical features cannot be fully examined because the bones in these fossils have been smashed flat—preserved in essentially two dimensions. Well-preserved, three-dimensional fossil material is vital to a better understanding of the entire question of bird origins.

Mongolia, a prime site for such material, has yielded both primitive birds and the small theropod dinosaurs thought to be close relatives of birds. One striking example is a rock-encased *Velociraptor,* a small, swift, carnivorous theropod dinosaur, entwined in a death struggle with a *Protoceratops,* a plant eater

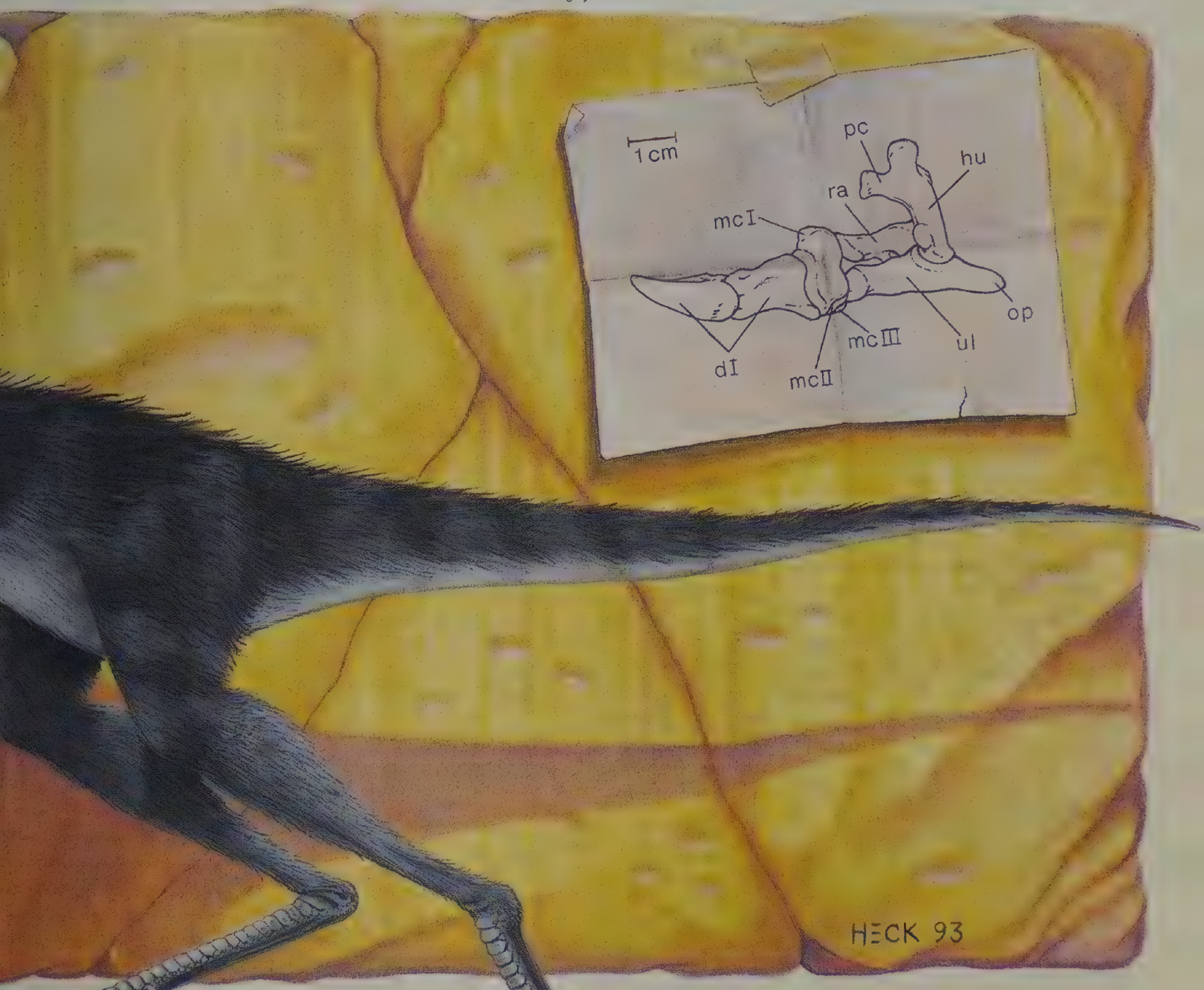


abundant in Cretaceous times. Among the world's paleontologic treasures, these fossils were discovered in the 1960s by Perle Altangerel (a Mongolian participant in our recent joint expeditions), and by Polish colleagues. During our first three field seasons in the Gobi, we, too, have had the good fortune to unearth several new dinosaur specimens; one of these has given us new insights into the origin of birds.

At the start of the 1991 expedition, we were in Ulan Bator, Mongolia's capital city, preparing for the two-month excursion to the Gobi, when Perle Altangerel showed us an unusual specimen, collected in 1987 in south-central Mongolia. At first, we could hardly believe that the bones were the remains of a single animal—they looked as if they belonged to two different crea-

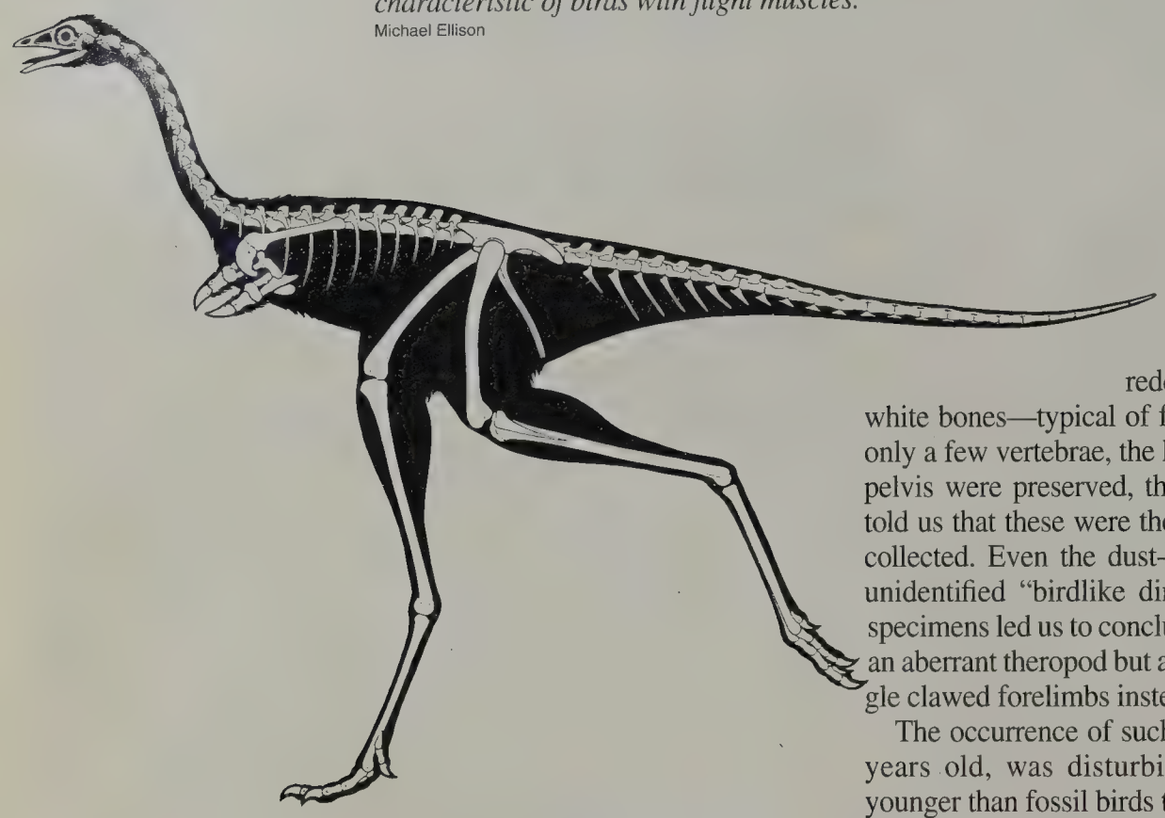
ree

Mononykus, *which lived some 70 million years ago in what is now the Gobi Desert, may have used its stout front claws for digging.*
Painting by Ed Heck



tures. But Perle assured us that they had been found in a single place with all of the bones articulated, or still arranged as in life. The hind limbs were long and birdlike, about the size of a turkey's, while the front limbs were tiny. Typically, in theropod inosaurs, if the front limbs are small, they are also eak. The front limbs of this animal were short and mall, but all of the bones had the sort of large protuerances and processes that one sees in heavily muscled urrowing animals. At the end of the arm, instead of the usual nultiple "fingers" seen in most four-legged animals, was a sinle, powerful finger terminating in a stout, hooked claw. For this reason, Perle had named the creature *Mononykus olecranus*, the genus name meaning "one-claw."

In our minds, we cataloged this fossil as an interesting anomaly until Perle brought it to New York during a visit in 1992. On seeing it again, we compared it with a specimen that American Museum paleontologist Malcolm McKenna had found in July 1992 about forty-five miles northwest of the Flaming Cliffs at Tugrugeen Shireh (the site that had yielded the dinosaurs locked in combat). Among the loose bits were bones that were smaller versions of the ones Perle had found. Associated with these bits, Malcolm had also found a small skeleton, which he excavated and encased in a plaster jacket. We began to extri-



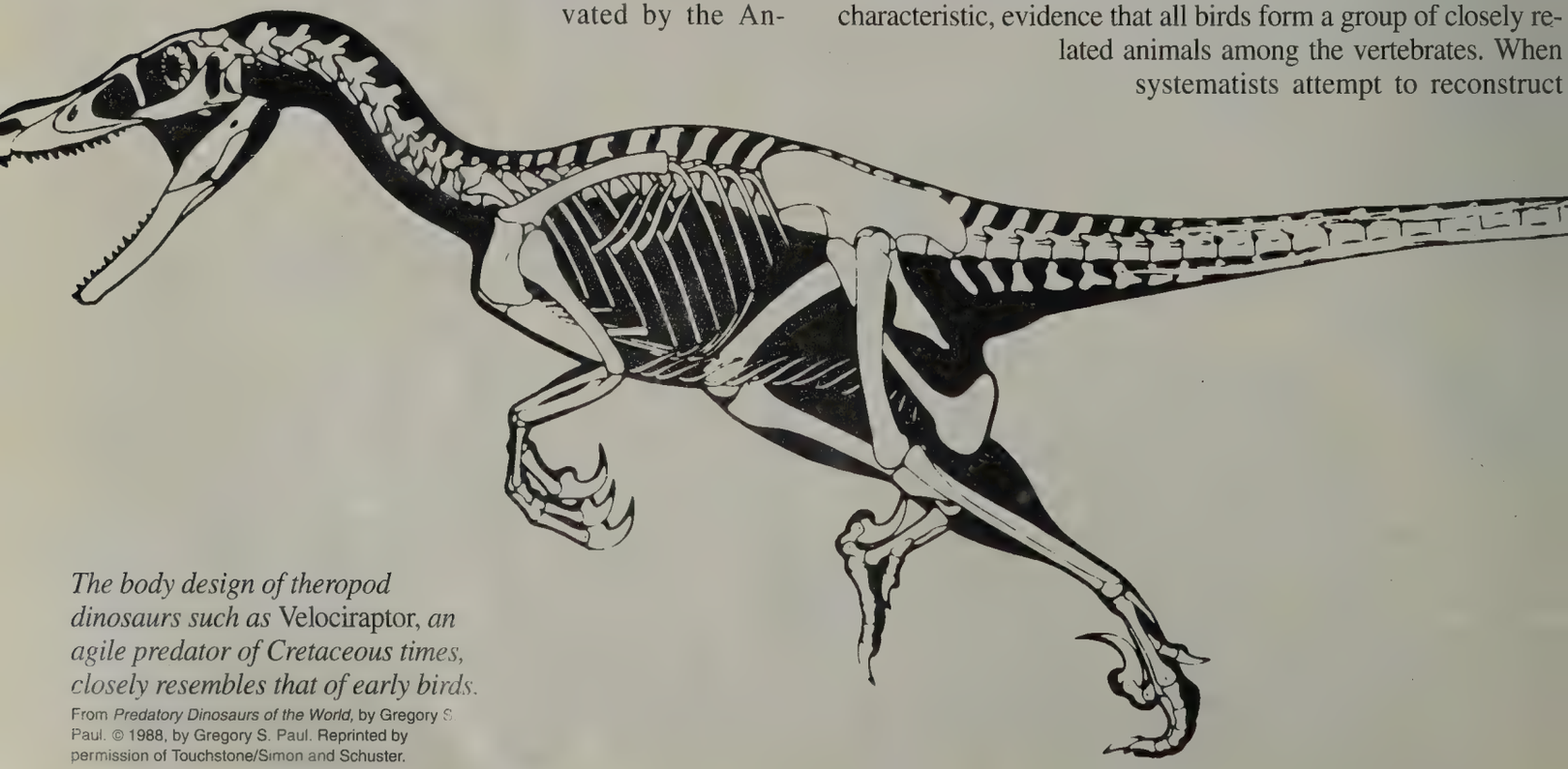
Toothed and long-tailed like many other small theropod dinosaurs, Mononykus *also has defining avian features. Although it was flightless, its keeled breatsbone is characteristic of birds with flight muscles.*
Michael Ellison

cate the specimen from its protective plaster block, and after a few days, the legs and tail of a small animal emerged. The hind limbs were structurally identical with those collected by Perle two years earlier at Bugin Tsav, but they were about one-third smaller, perhaps representing a juvenile. More important, this specimen, preserved in three dimensions, had a nearly complete pelvis, a long, articulated tail, and a complete foot.

During the spring of 1993, more specimens of this group turned up. One fragment had been collected during our 1992 expedition. Another had long been sitting in the Museum's own collection. Excavated by the Andrews expedition, it was brought to our attention by Bryn Mader, of the Museum's Department of Vertebrate Paleontology. It was a small, reddish lump with a few exposed, eroded white bones—typical of fossils from the Flaming Cliffs. While only a few vertebrae, the hind limbs, and parts of the distinctive pelvis were preserved, these sparse, heavily abraded elements told us that these were the remains of the first *Mononykus* ever collected. Even the dust-covered label proclaimed it to be an unidentified "birdlike dinosaur." Taken together, these three specimens led us to conclude that *Mononykus olecranus* was not an aberrant theropod but a primitive bird—a bird with short, single clawed forelimbs instead of a more typical wings.

The occurrence of such a primitive bird, at about 70 million years old, was disturbing because *Mononykus* was much younger than fossil birds that appear more advanced. Feathered, flighted *Sinornis* and *Iberomesornis,* for example, predate *Mononykus* by about 40 million years. In addition, both the more advanced, but flightless, diving bird *Hesperornis* and fully flighted ancestors of modern birds were contemporaries of *Mononykus.*

Our reasons for considering *Mononykus* a bird are based on the presence of several evolutionary novelties shared by *Mononykus* and birds. These novelties—or derived characteristics—are the criteria that systematists use to group organisms and to reconstruct their family trees. For example, all feathered vertebrates (birds) have backbones, but not all organisms that have backbones have feathers. So feathers constitute a derived characteristic, evidence that all birds form a group of closely related animals among the vertebrates. When systematists attempt to reconstruct



The body design of theropod dinosaurs such as Velociraptor, *an agile predator of Cretaceous times, closely resembles that of early birds.*
From *Predatory Dinosaurs of the World,* by Gregory S. Paul. © 1988, by Gregory S. Paul. Reprinted by permission of Touchstone/Simon and Schuster.



From "Early Evolution of Avian Flight and Perching: New Evidence from the Lower Cretaceous of China," by P.C. Sereno and R. Chenggang, *Science* (February 1992) 255:845–48, © AAAS

Feathered and probably able to fly, the crow-sized Archaeopteryx, *below, reflects a mixture of reptilian and avian traits. Both* Archeopteryx *and the sparrow-sized flying bird* Sinornis, *left, are much older than* Mononykus.

From *Predatory Dinosaurs of the World*, by Gregory S. Paul. © 1988, by Gregory S. Paul. Reprinted by permission of Touchstone/Simon and Schuster.

mily trees or place newly discovered ani-
ls like *Mononykus* into context, they
k for derived characters, such as feath-
, that are evidence for subgroups that
are a common ancestor.

Despite its lack of wings and the many
mitive features reminiscent of its dinosaur
cestors (including teeth, a long tail, and foot bones
at are separate from one another), the bizarre
nonykus had several birdlike characteristics that are not
und in *Archaeopteryx* specimens. These include a breastbone
th a strong median keel, a fibula that is reduced to a small
ike (like the thin bone of a drumstick), and fused wrist bones.
ese derived traits, shared with modern birds, place it firmly in
e subgroup with other avians.

What is the place of *Mononykus* in the evolutionary history of
rds? Currently, the oldest-known bona fide birds are the 145-
llion-year-old *Archaeopteryx* and the 100-million-year-old
eromesornis and *Sinornis*. Certainly, mononykosaurs
Mononykus and its relatives) have a lengthy history that is un-
corded in the fossil record, and the discovery of *Mononykus*
ll leaves great gaps in our knowledge of the evolutionary
ents that took place between *Archaeopteryx* and the origin of
odern birds. The specialized forelimbs and late geological age
Mononykus tell us that it cannot be a direct ancestor of mod-
n birds. We will continue to search both in the field and in our
useum collections for other kinds of mononykosaurs and to
e-tune the position of these animals in the family tree of birds
d theropods.



Mononykosaurs are animals of Dr. Seussian dimensions.
uch of the skeleton looks pretty average for that of a small
eropod. Only with the strange front limbs do we get into trou-
e. What could they possibly have been used for? Forelimb
odification is a recurring theme in theropods—both di-
saurian and avian. (Among these are the diminutive arms of
rannosaurus rex, the elongated arms of some Mongolian
eropods, and the flippers of penguins.) But the short, muscular,
awed arms of *Mononykus* are among the most bizarre we have
er encountered.

Living animals with strong, clawed front limbs are diggers.
he actual muscle power can be determined from the size of the
series of crests on the arm bones, which, in life, anchored big muscles. This musculature was further empowered by the architecture of the arm bones. The olecranon process of *Mononykus*, which is equivalent to our elbow, is as long as the forearm. Muscles attaching to the olecranon process give tremendous leverage to the forearm, in much the same way that a long-handled shovel works better than a short-handled one. The bone surfaces indicate that movement was predominantly in a single plane, with the massive fingers moving inward toward the middle of the body. Our best guess is that *Mononykus* was an animal that fed much as aardvarks or anteaters do today, using its brawny front limbs to tear apart plants (or perhaps insect nests) while foraging on the ground.

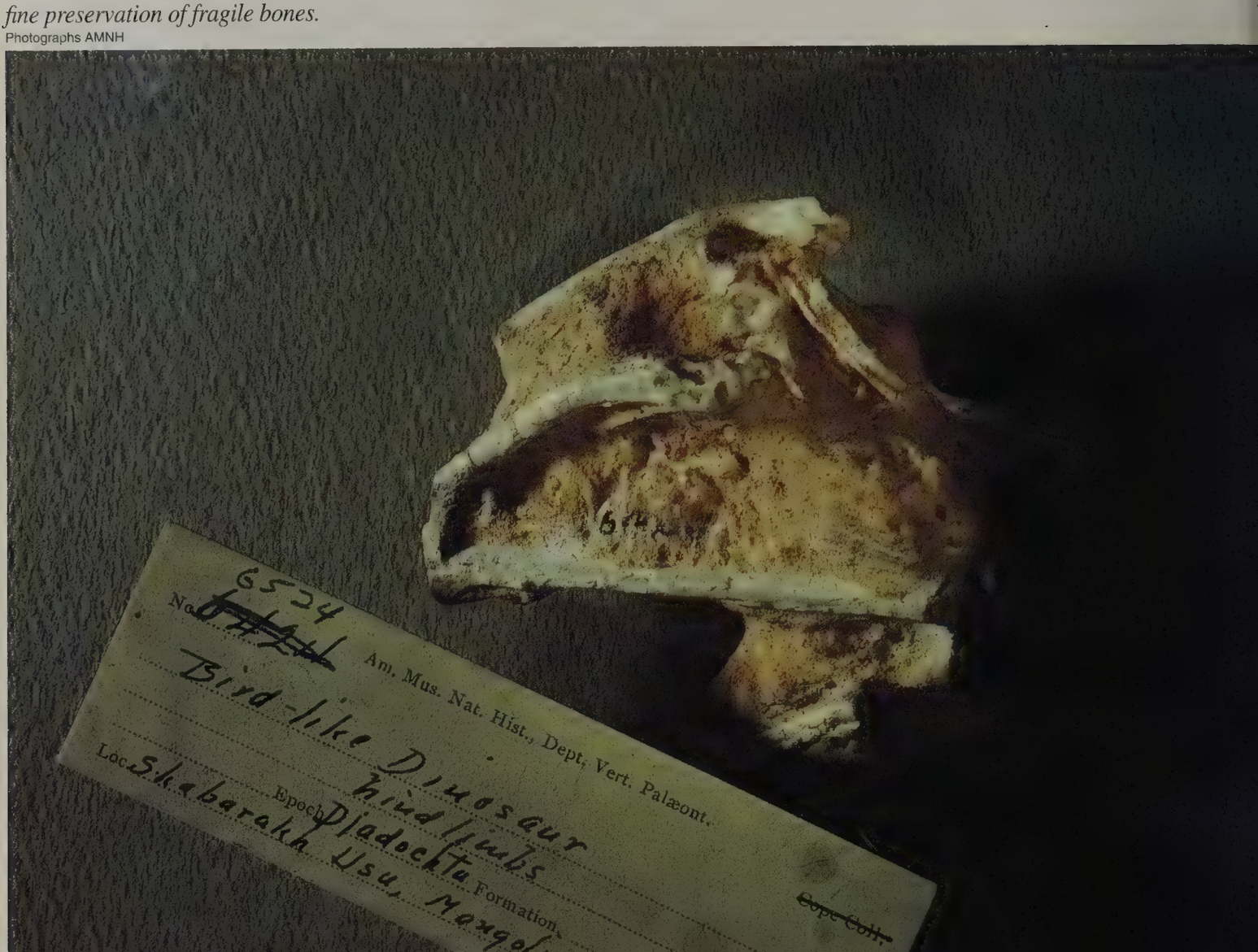
Present-day birds have highly modified forelimbs, usually associated with the evolution of powered flight. These specializations include a reduction in the number of digits (birds have just one primary digit homologous to a single human finger), the fusion of all the wrist bones into a single inflexible element, and a reorientation of the top of the upper arm bone. These forelimb specializations link *Mononykus* with modern birds.

But this complicates the story of the origin of flight. Most authorities feel that *Archaeopteryx* could fly, although just how adept a flier it was is a matter of debate. More advanced birds like *Sinornis* and *Ibermesornis* definitely flew. *Mononykus*, however, was undoubtedly a ground dweller. Its privileged position in the avian family tree—nearer to modern birds than to *Archaeopteryx*—suggests two very different, but plausible, scenarios for the evolution of flight.

In one scenario, the common ancestor of *Archaeopteryx* and modern birds had some degree of powered flight, but the ability to fly was later lost in the lineage leading to mononykosaurs, as

Labeled "birdlike dinosaur," Mononykus *fossil fragments, below, were excavated during the 1923 Gobi expedition. This American Museum specimen and more complete fossils fresh from the field revealed that* Mononykus *was a flightless bird. The remains of* Archaeopteryx, *right, are among the best and earliest examples of fine preservation of fragile bones.*

Photographs AMNH



it has been in birds such as kiwis, ostriches, and some rails. In the second scenario, the original bird ancestor was flightless, and the ability to fly arose twice—once in the lineage leading to *Archaeopteryx* and again in the lineage leading to modern birds, some time after mononykosaurs split off from the latter line. This second possibility has important ramifications—if it is true, then *Archaeopteryx* may not be relevant to the origin of what we think of as modern bird flight. Instead, our inquiries should focus on the ground-dwelling *Mononykus* as the closest relative of the first modern flying birds.

Could flight have arisen twice in the history of birds? This scenario is not as convoluted as it may seem. *Mononykus* does exhibit a keeled sternum for attachment of developed muscles and the fusion of the wrist bones. Conceivably, these elements arose in *Mononykus* ancestors for some other function, such as digging, and were subsequently co-opted for flight.

As paleontologists and systematists, one of our goals is to understand how organisms interrelate. As more creatures like *Mononykus* are discovered, the family tree is readjusted to make room for the newcomers and often to reflect new thinking about relationships within groups. In our wildest dreams, we would never have imagined that our best-preserved representative of the early evolution of birds would be as unusual as *Mononykus*. The discovery of such specimens shows that the boundary between modern birds and their typically dinosaurian ancestors is a diffuse one and that the path of early bird evolution is a circuitous one. The true importance of *Mononykus* may be the unexpected twist it adds to the story of early bird evolution. □



Barking Up the Right Tree

olorado's tassel-eared squirrels live in edible homes

/ Marc A. Snyder and Yan B. Linhart

Eating pine bark is a tough way to make iving. It's sticky, gummy, stringy, and t very nutritious. Yet from late fall, ough winter, and well into spring, inner rk is about all the tassel-eared squirrel n find to sustain itself in the pine forests the Southern Rockies in the United ates and the Sierra Madre Occidental in exico. During the early summer, this ndsome animal—also known as Abert's uirrel— feeds on pine pollen, fungi, and ds. Through the summer and into early tumn, it eats pine seeds as well. After at, the squirrel feeds almost exclusively bark from only one species of tree: the nderosa pine.

With such notable exceptions as bam-o-eating giant pandas in Asia and euca-ptus-eating koalas in Australia, few ammals are as closely tied to specific ants as are tassel-eared squirrels. They e only among ponderosa pines and de-nd on these trees for both shelter and od. High in tree crowns, the squirrels nstruct bushel-basket-sized nests from tertwined twigs, lining them with pine edles and grasses from the forest floor. ests are sturdy and well insulated. With eriodic maintenance, they protect the uirrels from weather and predators, offer em a comfortable place to rest, and serve a safe nursery for their young. Mating kes place in the spring and early sum-er, following complex chases that usu-ly involve a female and several males. fter six to seven weeks of gestation, a lit-r averaging three to five babies is born. ne young remain in the nest six to seven eeks before venturing forth.

Individuals vary in coat color. In the olorado Front Range, we commonly see imals that are completely black; others at are grizzled gray with a white belly, old black lateral stripes, and often a wash red extending from the ears to midway own the back; and still others that are ble brown to cinnamon in color. Re-arkably, we often see two or three color nases within a single litter.

For the first few weeks after emerging

A tassel-eared squirrel, facing page, climbs a ponderosa pine trunk. Alternating dark and light bands on individual hairs give the animal's coat its grizzled appearance. Tassel-eared squirrels with black coats, such as the individual below, are more common in the northern part of the species' range.

Photographs by William Ervin



A squirrel pauses to groom itself in Colorado's Boulder Mountain Park, which is in the Front Range of the Rocky Mountains.
Robert and Jean Pollock





from the nest, juveniles stay in, or very close to, their nest tree. Siblings play together animatedly, practice acrobatic leaps between adjacent trees, and sample the various foods available during the pleasant montane summers. During this period, youngsters may get their first taste of inner bark, tentatively scraping it from the upper side of branches high in the nest tree. (Adults, however, do not usually feed in nest trees.) As summer wanes and seeds fall from opening pine cones, the squirrels begin to rely almost exclusively on the bark. Unlike many other squirrels in temperate habitats, Abert's squirrels neither cache food nor hibernate during cold winter months. While youngsters' initial attempts at bark feeding are inefficient, adults process twigs in a series of well-defined steps.

First, the squirrel gnaws off a shoot, usually in the upper crown of the tree, then severs the terminal needle cluster, leaving a bare twig about one to eight inches long. Holding this section between its forepaws, the squirrel scrapes off the outer bark and feeds on the inside layers. Afterward, it drops the remaining wood to the ground below. A squirrel may repeat this process dozens of times before moving on to another tree. The resultant accumulations of clipped needle clusters and bare "bones" of wood littering the forest floor, coupled with the ragged appearance of defoliated crowns, easily identify a squirrel's favorite food trees.

Why do Abert's squirrels choose particular trees and leave others untouched? Do squirrels select trees on the basis of nutrients? Or are they simply avoiding noxious substances that are present in some trees but not in others? And how are the trees affected by the squirrels' feeding?

Although their forest habitats contain hundreds of trees per acre, and individual squirrels range over many acres, the squirrels are fussy, and relatively few trees seem to satisfy them. One of their criteria is that twig processing should not be unpleasant. When squirrels gnaw through twigs, they sever resin canals in the wood. Because resin pressure varies from tree to tree, and fast-flowing resin can quickly gum up their paws and mouth, squirrels tend to prefer trees with slow resin flow. In addition, ponderosa pine resin contains a variety of chemical compounds, such as monoterpenes, that vary greatly in toxicity and odor. Even humans, with their comparatively unsophisticated sense of smell, can differentiate among resin odors, which can be reminiscent of vanilla, butterscotch, chocolate, and turpentine. Two monoterpenes, ß-pinene and ß-phellandrene, appear to be especially offensive to tassel-eared squirrels, and they seem to avoid trees containing pronounced levels of either.

We decided to test whether the trees selected by the squirrels have naturally lower resin flow and monoterpene levels or whether these characteristics are induced by the squirrels' feeding activities.

William Ervin



Left: The stunted, defoliated pine (right) has been visited by bark-feeding squirrels for nine consecutive years. Its healthy neighbor (left) has been ignored—and allowed to prosper—because squirrels find its resins unpleasant. Below: Clumps of pine needles and stripped twigs on the ground are sure signs of bark-feeding squirrels. Often, mule deer and hares graze on the discarded needles.

Robert and Jean Pollock



For several years, we clipped twigs and needle clusters from the upper crowns of dozens of trees, but our simulated "feeding" induced no changes in the resins.

We also set up feeding trials in nest trees to test whether squirrels actively avoided monoterpenes, as we suspected. Proffered delicacies—small packets of peanut butter—allowed them to choose among treats that were either unaltered or slightly to heavily laced with ß-pinene or ß-phellandrene. Results were unequivocal; the animals consistently chose the plain peanut butter, but ate significantly less of the lightly laced offerings and even less of the heavily laced variety.

However, the squirrels' feeding choices are not dictated solely by the repellent features of these pines. Nutritional value is also a factor. Preferred trees are relatively high in carbohydrates and sodium, which squirrels probably like for the same reasons that we do: carbohydrates provide energy, and sodium is an essential mineral for metabolism. Conversely, squirrels avoid trees that contain significant levels of iron or mercury, both of which can be poisonous in high concentrations.

We therefore examined attributes—resin flow and chemistry—that are known to be controlled genetically. We wondered whether tassel-eared squirrels could be agents of natural selection in the ponderosa pine forests they inhabit. We examined this herbivore–host relationship from the pine's perspective. A tree's food is produced in its leaves via photosynthesis, and is used for general maintenance and reproduction and to fuel growth. Can ponderosa pines provide squirrels with unlimited food without suffering ill effects, or does repeated defoliation eventually damage a tree's health and reproductive capacity, and ultimately shorten its life span? Generally, once specific trees have been identified as being especially desirable, squirrels return to them often. Some trees at our study sites have been used for at least nine consecutive years, and others over the course of two decades.

After a four-year comparison of growth and reproduction rates between trees used by squirrels and those they left alone, we found our answer: repeated squirrel feeding seriously affects the trees' well-being. Under normal circumstances, pines grow rapidly during spring and summer, slow down late in summer, and stop growing in winter. When viewed in cross section, tree rings (which record annual growth) are visible as alternating bands of pale-colored (fast growth) and dark-colored (slow growth) bands. When trees are stressed, they produce narrow rings. Using a sampling instrument that extracts pencil-thin wood cores, we measured rings and learned that trees favored by squirrels grow much more slowly than their neighbors, probably because of chronic needle losses from twig-clipping.

Bark feeding by squirrels affects not only a tree's growth rate but also its ability to reproduce. A pine's female cones

Pat and Tom Lees

Its long white tail identifies a tassel-eared squirrel, right, as member of the Kaibab subspecies, an isolated population foun only on the North Rim of the Grand Canyon. Below: Havin gnawed off an appropriate twig for feeding, a Kaibab squirr clips the pine needle cluster from its ti

Pat and Tom Leeson; Photo Researchers, I



measured by counting the pollen-bearing male cones and the seed-bearing female cones. Trees that are defoliated for their inner bark produce only about one-tenth the number of male and female cones produced by uneaten trees. That translates into only one-tenth of the potential fertilizations and potential progeny of untouched trees. By any measure we care to use, the squirrels' favorite trees appear to be in trouble.

Given the squirrels' effects on trees, they appear to act as agents of natural selection. But we do not yet understand all the complexities of squirrel–pine interactions. The animals might appear to be eating themselves out of a replenishable source of groceries, but they have been associated with ponderosa pine stands for millennia. Why haven't the squirrels eliminated all the trees with suitable characteristics? First, squirrel population densities can fluctuate wildly, which may allow some trees to recover between concentrated assaults. Second, a number of squirrels may miss suitable trees, while new ones are maturing all the time. Many trees probably grow to maturity before being recognized as suitable hosts by the squirrels. Finally, a number of trees grow some distance away from the safe arboreal routes within dense stands of pine that are normally favored by the squirrels. Some of these trees may be chemically palatable, but because their relatively isolated locations might expose the animals to the dangers of sprinting across open ground, the avoid them.

Feeding on the inner bark of ponderos pines is not a habit confined to tassel-eare squirrels. In winter months, when food scarce in the Southern Rockies, severa other mammals resort to bark-feedin mice, rabbits and hares, as well as mul deer, elk, and bears. In the past, some Na tive American tribes also utilized this foo source during difficult times. No othe mammal, however, has been so com pletely dependent on this low-quality re source as the tassel-eared squirrel. Onl their well-developed ability to explo inner bark allows them to survive in an en vironment that, for much of the year, o fers little else. □



Photographs by Thomas L. Kelly

Two Gabbra survey camel stock, deciding on a trade. The man with the headdress is a political elder, responsible for providing day-to-day social order.



Nomads on Notice

Can Kenya's Gabbra survive drought, bandits, and foreign relief?

by Daniel Stiles



Northern Kenya is a land of extremes, with wind-blasted volcanic wastes in the lowlands and lush tropical forests on isolated mountains. The territory is divided among several tribes that vigilantly defend their domains. The Gabbra pastoralists, who number about 35,000, cluster around the cracked, salt-encrusted mud flats of the Chalbi Desert and along the eastern shore of Lake Turkana. Because rainfall is sporadic and localized, water sources and vegetation are scattered and unpredictable. (Oases near the lake often provide fresh water, but the jade-colored lake itself is bitter with accumulated salts.) The Gabbra must move periodically, often splitting up their camps to take advantage of nature's meager offerings.

The keys to the Gabbra's survival are mobility, hard work, and cooperation. During their lives, married men go through various life stages, becoming at different times "political elders" and then "ritual elders." Along with those chosen for specific leadership roles, these elders control Gabbra life and also provide moral guidance.

The Gabbra separate their herds of camels, cattle, sheep, and goats by species, age, and whether or not they are giving milk. Milk is the traditional staple, followed by meat and then blood, but the Gabbra now commonly buy cornmeal through the sale of small livestock. They keep milk-giving animals at the main settlements (*ola*) and, to avoid overgrazing, send the dry ones and most males off to distant locations. Because of the danger of raiding by other tribes, young warriors usually run the satellite camps, called *fora*. The zones separating enemy tribes are sparsely inhabited.

One of the insecure zones is around Koobi Fora, paleontologist Richard Leakey's research site. In 1971, while I was there on my first trip to northern Kenya, a raiding party of a neighboring nomadic group, the Dassenech, came across the border from Ethiopia, sending the Gabbra running and scaring the wits out of the researchers and camp crew. The Dassenech had guns; the Gabbra didn't.



In a few hours, the Gabbra can pack a settlement, tents and all, on the backs of their camels and be on their way to an area where rain has fallen. The household effects are simple: aluminum cooking pots; wooden and woven fiber containers for storing milk, meat, and fat; bed poles and sleeping skins; and various ritual sticks that symbolize status (for a young man, a married man, a father, a married woman, an elder, and so on). Between 6:30 and 11:30 one morning, I observed four women in an area called Bubissa pack up their four families' skin tents, along with their pole frameworks and assorted contents, and load them onto the backs of groaning camels. The four households then set off on camels across the stony plains to go to Maikona, a two-day walk. A settlement may move up to ten times a year, depending on grazing conditions and security.

The Gabbra define four seasons, according to temperature and rainfall. Although conditions vary from year to year, generally the long, heavy rains come between late March and early June, followed by the cool dry season from June to September. Short rains arrive in October and last until early December, when the ho



Goats, left, are herded for their meat, consumed mostly on ceremonial occasions. Sold for cash, small livestock also provide the means to buy cornmeal and other necessities. The Gabbra and other largely pastoral groups, map below, occupy arid lands where agriculture is marginal. Huge Lake Turkana yields fish, but its waters are too brackish to be used for extensive irrigation.

Joe LeMonnier



ry season sets in. During the dry periods, ne Gabbra tend to live in small settle- nents grouped around permanent water ources, while in wetter times they occupy arger, more widely scattered settlements. When water becomes available in rain ools, for example, the otherwise dry Huri Hills become a favored pasture area. Three times a year, as many family mem- ers as possible, together with their live-

stock, gather at the *ola* for a *sorio*, a ceremony to bless the community and the livestock and to pray for rain and fertility.

Camels make up the bulk of the tribe's holdings, and without them the Gabbra could not live where they do. As beasts of burden, camels enable the Gabbra to move the *ola* rapidly to find fresh pasture after a cloudburst. Camels also transport water to the settlement, permitting an *ola* to be situated in good pasture as much as thirty miles from water. The Gabbra prefer to have female camels, with as many lactating ones as possible. In dry lands, camels provide much more milk than cattle do, lactating on average for at least a year after bearing a calf. A good camel can give more than two and a half gallons of milk a day during the rainy season and two to five quarts during the dry season. In contrast, a typical cow lactates only seven to nine months, giving two quarts of milk a day when pasture is lush and just a pint a day—and eventually none at all—during the dry times.

Camels also do less damage to the environment than other livestock. Their soft feet do not scuff up topsoil, causing it to blow or wash away, as hoofs do; and they feed on various types of vegetation, particularly leaves, so that the land does not lose the soil-conserving grass. Owing to the camel's relatively varied diet, its milk is higher in vitamin C and certain other nutrients than cattle milk.

Despite their sense of separate identity, the Gabbra are of mixed origins, in part derived from neighboring peoples. Arriving in the region in the late [illegible] century, mainly from Ethiopia and from further east in Kenya, they took the land they now occupy from the Rendille and Sam-

A camel's two teats must be milked simultaneously, below, or else one will temporarily withdraw out of reach. The milk, right, is a staple in the Gabbra's traditional diet.



buru, who were squeezed to the south. They have since defended their territory successfully against invasions by the Turkana, who live west of Lake Turkana, and the Masai, who once occupied much of central and southern Kenya.

The Gabbra retain a reputation as fierce warriors. In greeting and prayer, however, they often use the word *nagaya*—"peace"—a cultural trait they share with Semitic peoples of western Asia, who are members of the same Afro-Asiatic language family. They particularly abhor strife within the tribe. I once witnessed two children, a boy and a girl, get into a fight. The boy hit the girl on the head with a rock and knocked her down. While I was treating her wound with antiseptic, several adults ran around seemingly in a panic. By the time I had finished and calmed the girl down, the parents had organized an expiation ceremony on the spot. They recited prayers and sacrificed a sheep offered by the boy's parents. I received a goatskin bracelet made from the sacrificed animal, signifying welcome and peace.

Water is critical for survival in the desert, but the Gabbra carefully avoid fighting among themselves over access to the few wells and water holes. At the height of the dry season, hundreds of thirsty camels, cattle, sheep, and goats may bellow for water and kick up clouds of dust around a well as their herders struggle to keep them at bay and await their allotted turn. The "father of dividing," selected by the political elders (and almost always one himself), schedules each herd by species and ownership. He must be a man of fairness and iron will.

A chain of six or eight men position themselves in the well on dug-out ledges, projecting rocks in the wall, or scaffolding and pass the traditional giraffeskin containers up and down. The wells are often called "singing wells" because the men keep up a rhythmic chant as they draw the water up by hand from a depth of as much as fifty feet. The animals drink from a trough of molded mud, which needs constant repair from the damage caused by their jostling.

One of the biggest problems the Gabbra face is fulfilling labor needs. Averaging the wet- and dry-season regimes, researchers have calculated that nine people must work nine hours a day, every day, to mind one family herd and take care of the various household chores. To find the necessary labor, the Gabbra draw on a network of kinship and other social ties to look after the subdivided herds at the *ola* and the outlying camel, cattle, and small livestock camps.

In doing censuses, I learned that many more people are attached to a household than mom, dad, and the kids. For example, Wario Guyo, his wife, Shanu, and their young daughter slept in their house, while Wario's two nephews and an unmarried brother-in-law slept behind a thorn-branch windbreak out by the camel corral. A man belonging to a lower-status subgroup, the Wata, not allowed by tradition to sleep in the *ola*, lived to the west in the shade of an acacia tree. These additional household members each had a different herd o Wario's to care for and were paid in kin by food and stock offspring. Away from the *ola*, which was located on the eastern margin of the Chalbi Desert, two o Wario's sons looked after a *fora* near Lak Turkana, and the third was in school a Mount Marsabit, about sixty miles away.

To discover how many animals people owned, I had to unravel various types o loans and ownership arrangements. On young married man, Dub Boru, explained that most of his animals still belonged t his father, and that he had received them a an advance on his inheritance. He also ha three camels and several sheep and goat that his *abuya*, a special uncle, had given him on important occasions, such as his circumcision. Dub also managed severa milk camels obtained on loan. In exchang for taking care of the animals, he was enti tled to their milk and their offspring, bu had to give all subsequent generations o animals to the owner. Counting all the an



nals at Dub's *ola* and out at the *fora,* I es-
mated that he controlled at least eight
ctating camels, two lactating cows, ten
her adult camels, seven camel calves,
ur other cattle, and about sixty sheep and
oats (small livestock reproduce quickly
nd are often sold or slaughtered, so exact
gures are hard to come by). These ani-
als provided food for six adults and ado-
scents and eight children.

Dub also exchanged animals. When his
econd child was born, for example, he
aded one of his transport camels for a
ctating cow; and when he needed money
r cloth for his wife and school fees for a
ster's son, he traded a heifer camel for
n goats, which he then sold. (Gabbra do
ot sell camels directly for money, for they
fear this would bring misfortune.) Even with these maneuverings, Dub's animals weren't always sufficient to feed his family, owing to fluctuations in milk supply. So he pooled his herd with that of his brother-in-law, who was in a similar situation. The combined herds provided a more reliable source of milk.

The right of personal ownership does not, in the Gabbra's view, permit a man to monopolize more animals than he and his dependents need for survival. Through loans and gifts, excess animals are redistributed to the needy, allowing the whole community to survive. The secular authority of political elders and the moral authority of ritual elders insure that these mechanisms of social cooperation are respected. One old man, Guracha Galgallo, is famous for owning about one thousand camels and many cattle and small livestock. Yet he dresses as all other Gabbra do, lives in the same style house, and eats the same food as the poorest Gabbra (although probably more regularly). Most of his animals are out on loan to those who have need of milk or transport or a bull for mating. His reward is respect.

The redistribution of livestock maximizes their use for food, transport, and cash. When there is a real surplus of animals, more than needed to meet the food requirements for the community as a whole (a rare occurrence), they are sacrificed and consumed at special ceremonial occasions to thank Waqa, the supreme being. As a result, the burden placed on the fragile environment is kept to a minimum. In contrast, many cattle pastoralists with more restricted systems of redistribution accumulate great numbers of animals. While their herds serve as insurance against drought and other calamities, they can cause serious land degradation.

Because food is usually in short supply, the Gabbra store little, although they have the technology to do so. For example, milk is soured and made into a kind of yogurt that lasts for weeks. And pieces of meat, stored with fat in small woven or wooden containers, can keep for more than a year. With food resources fluctuating from season to season and year to year, a group must manage enough animals to survive the worst conditions. To get by, an average family of six needs about twenty-eight camels, including six to eight that are lactating, or the equivalent in other cattle. Unfortunately, in 1991 drought and an undiagnosed camel disease reduced the herds below this level.

When the Gabbra and other northern Kenya pastoralists experienced hard times in the past, they always managed to endure. But now they are receiving food relief, and foreign relief agencies and Westerners are exerting great influence on them. Because of the scarcity of livestock—and deteriorating [illegible] the troubles in Somalia [illegible]

A Gabbra woman dismantles the framework of her tent, below, as she prepares to move her household. Fully loaded, left, a camel can travel fifty miles a day.



raiding has also become much more frequent. Some Gabbra have moved to refugee camps to escape armed bandits.

If the neighboring countries regain political stability, and if the rains return, the Gabbra's traditional life should improve. But the last time I visited Gabbra country, I was not encouraged. Outsiders—famine relief workers, development-aid workers, missionaries, teachers, and government officers—are telling the Gabbra that they are backward and primitive. They are urging some to move to settlements on nearby Mount Marsabit and learn how to grow crops. There they would join Ethiopian immigrants, mission-settled refugees, southern Kenyan traders and administrators, and others who are encroaching on a "protected" national park forest.

Most Gabbra I know are horrified at the thought of taking up cultivation. One man, a ritual elder named Elema Arbu, told me that becoming a farmer was equivalent to becoming an outcast. "Without livestock, how can I provide bride price for my sons? How can I pay my stock debts? How can I make *sorio* and other sacrifices? How can I give the stock gifts at my nephews' circumcisions? Without herds, how can I hold my head up?" □





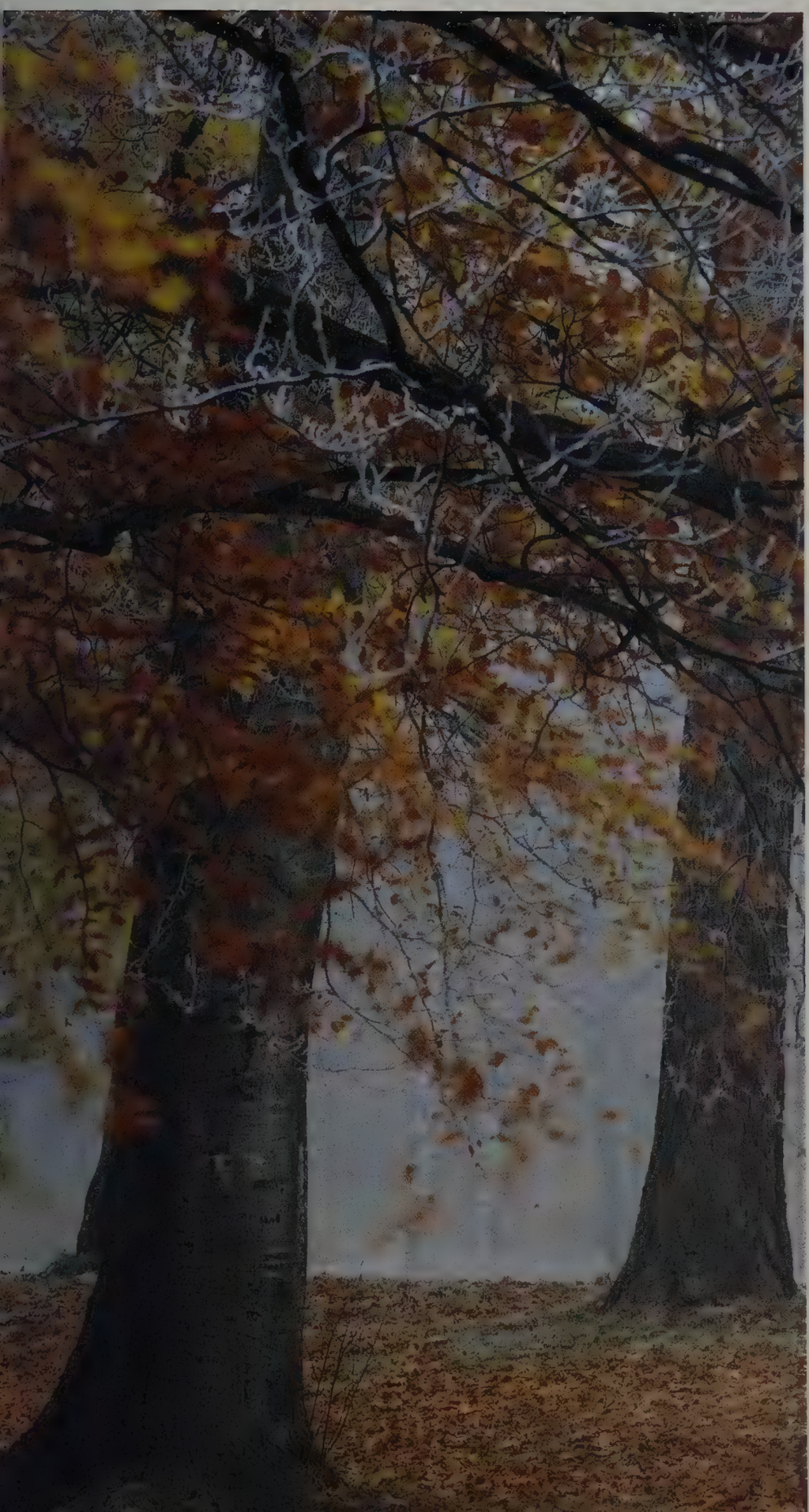
In autumn, when they have lost many of their leaves, trees are less likely to be damaged by a strong wind than in spring and summer.
Mattias Klum: Tiofoto



When Leaves Save the Tree

In violent gales, trees might topple if not for the aerodynamic design of leaves

by Steven Vogel



The arrangement of leaves on a tree is not haphazard; it assures the efficient interception of the sun's rays for photosynthesis. As the shadow cast by a tree attests, little sunlight is wasted. And one suspects that as little wood as possible is used to support the great weight of the green canopy. But the design of a tree and its leaves is also determined by wind. When gentle breezes turn into violent gales, the sideways drag of the leaves in the wind becomes a greater threat than the downward pull of gravity. The tremendous surface area of leaves becomes a major liability instead of a virtue. Exceptionally powerful storms can blow a tree over, either uprooting it entirely or splintering its trunk.

Few trees can survive such trauma, and if they have not reached reproductive maturity, they will leave no progeny. Because many long-lived tree species postpone reproduction for decades, this point is not trivial. For a tree that delays reproduction to age twenty and that is vulnerable to the violent kind of wind that occurs, on average, every five years, the chances are slim that it will contribute to the next generation. Should we be surprised then, to discover that trees have evolved a number of wind-resistant designs?

To survive the strongest winds, trees need two things. The most obvious is structural support—strong, flexible branches, stiff trunks, wide bases, and good root anchorage. A more subtle requirement is leaves that have minimal drag in high winds. The latter requirement is the more interesting to me because no human-made structures exist that can give us much insight into how trees behave in high winds. To minimize drag, engineers usually resort to streamlining, a most effective way of easing flow around an object. (Drag is generated when any fluid flows around an object. The amount of drag depends on the amount of friction between the fluid and the surface of the object, as well as the object's general shape.) A highly streamlined object—gently rounded upstream and elongated and pointed downstream—will experience

Leaves of an American holly clump together as the speed of the wind (blowing from left to right) increases. In winds of 30 mph, leaves lie flat against one another, reducing drag to a minimum.
Photographs by Steven Vogel


0 mph


20 mph

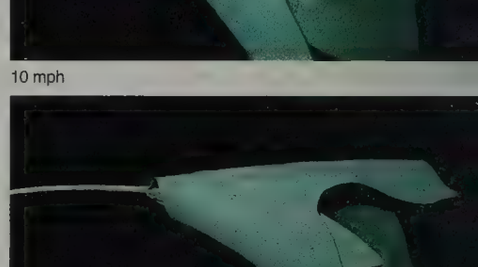

25 mph


30 mph

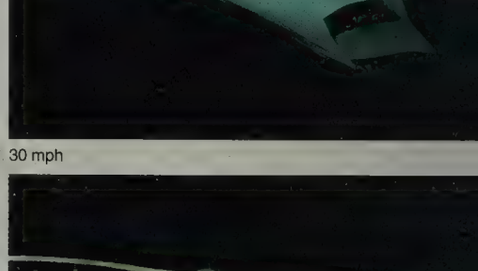
As wind speeds increase, a tulip tree leaf gradually rolls itself into a tight cone pointing into the wind.


0 mph


10 mph


20 mph


30 mph


40 mph

less than 10 percent of the drag of a sphere or a cylinder of equal volume. And compared with these simple shapes, trees are geometrically bizarre. Even a careful look at one fails to reveal anything remotely resembling streamlining.

Most of a tree's weight is in its trunk and main branches, but by far the largest part of its surface area is in its leaves. And the more surface area, the more drag. Trees most commonly blow over when in full leaf—despite the shelter provided by their leafy neighbors.

The situation is even worse than a strict accounting of total surface area would suggest. Most leaves are fairly flexible, more like flags than, say, rigid plates. One might guess that a flag, adjusting its contours to follow the passing air flow, would have less drag than a rigid plate. But the opposite is true—a flag typically has several times the drag of a plate. (Don't decorate your airplane with flags, and don't tack in a sailboat flying a large flag.)

On the other hand, flexibility can be a virtue if it can reduce exposed surface area. Several sorts of large algae, both marine and freshwater, can collapse their fronds into ever tighter bundles as they're exposed to more rapid water flow, a process that proves quite effective in keeping drag down at high speeds. In essence, by rearranging their fronds, the plants gradually reduce the exposed surface as the speed of flow increases.

What, then, might trees do to reduce drag? Initially, I tested a few leaves in a deliberately turbulent wind tunnel (to mimic natural conditions) at gradually increasing wind strength of eleven, twenty-two, thirty-three, and forty-four miles per hour. Two things struck me immediately. First, most leaves were stable. While flags always fluttered, not all of the leaves did. Second, the leaves that did not flutter were gradually transformed, typically into cones that became increasingly tight in stronger winds. The blade of a leaf in the wind trailed downwind from its stem, and the wide base of the leaf rolled to form the cone's apex.

I followed up my observations with photographs and with direct measurements of drag. Relative to their surface areas, the conically curled leaves behaved much more like weather vanes than like flags. They experienced only about a third the drag of a square flag of equal area. Furthermore, the leaves performed better, comparatively speaking, at the higher wind speeds. I believe this reconfiguration happens in real storms, but the rapid changes in speed and direction of the wind and the constant thrashing of branches simply obscures the phenomenon.

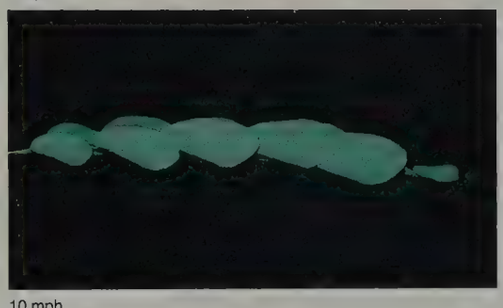
Still, not all leaves form cones. Among those immediately available for me to test, red maple, tulip tree, sycamore, swee gum, and redbud leaves all rolled up. (make sure I was not observing the beha ior of dead leaves, I tested leaves a fe minutes after I had picked and rushe them to my wind tunnel.) What the leaves have in common are long stems a wide bases that flare backward toward t stem. These ordinary features of leave which may be unimportant under ever day circumstances, may be crucial to tree's survival in a storm.

Another surprise came when I teste compound leaves with leaflets arrayed rows on either side of a central stem. Bla

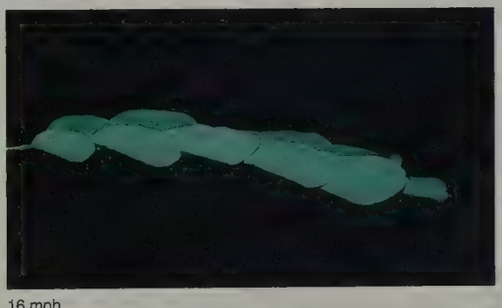
When the wind picks up, the leaflets of a black locust roll together to form a single cylinder.



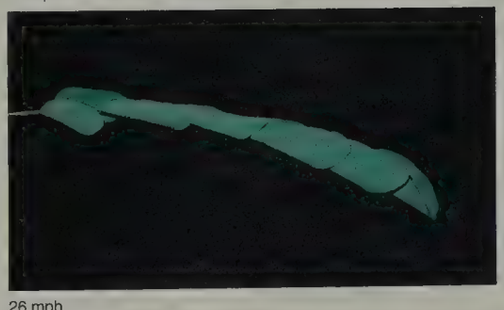
0 mph



10 mph



16 mph



26 mph

ıst and black walnut leaves reconfig-
d themselves as cylinders rather than
es, with the leaflets of each leaf curled
vard and backward to form the wall of
ingle, long cylinder. With increasing
ıd, the cylinders got tighter. Relative to
ir surface areas, the drag of these com-
ınd leaves was even lower than that of
simple ones.

White oak leaves, however—which
k wide lobes at their bases, long stems,
l independent leaflets—did very badly.
eir drag increased disproportionately at
h speeds, and they fluttered violently
l frequently began to tear in winds of
rty-five or forty miles per hour. White
k leaves, in short, were thoroughly
glike. Why hasn't this very tall and
mmon tree evolved better foliage? My
servations of various leaves in low
nds hint at the answer. Leaves do best,
otosynthetically, when their blades are
rpendicular to the light source, either di-
t or indirect sunlight. As the wind in-
eases, that orientation is lost. White oak
ves, with short stems and fairly stiff
ades, stay close to what might be called
"still air" orientation in stronger breezes
an do the leaves that reconfigure well at
gh speeds. Red maple leaves, for ex-
mple, will show their brighter undersides
a breeze that leaves an adjacent oak
ite unruffled. I suspected a trade-off;
hite oak leaves may gather more sun-
ht in strong breezes, while the tree's es-
cially stiff, strong, and dense wood com-
nsates for the increased drag of its
ves. Perhaps the white oak has more
od than do other trees relative to the
ea of leaves each supports.

A leaf, of course, is not necessarily an
dependent actor as it continually
anges shape and orientation in passing
sts. Leaves are usually borne in clusters,
I tested these as well. Given company,
ose leaves that formed individual cones
w formed big, communal, and still quite
able cones. Drag relative to area was also
bit lower for communal cones than for
dividual cones. Clusters of white oak
aves, while still not the best in either ap-
earance or drag reduction, clumped de-
cently and fluttered much less than indi-
viduals. The very stiff individual leaves of
the holly tree folded together to form flat
sandwiches reducing the exposed area and
drag. Even larger groupings of leaves may
play yet other tricks on a scale too large for
me to test in my wind tunnel. After all, en-
tire trees withstand winds higher than the
forty-four miles per hour speed that I
found damaging to most singly exposed
leaves and many clusters.

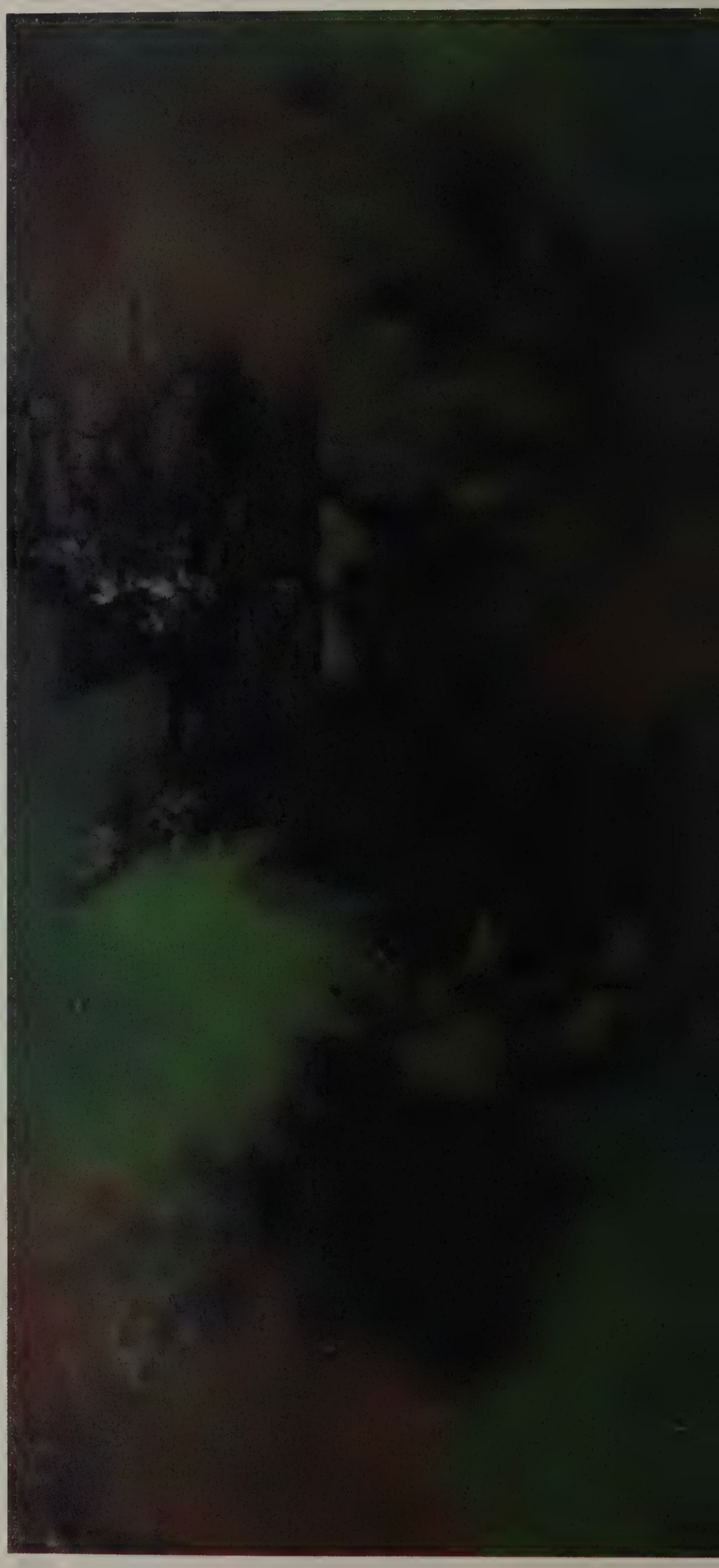
I could not claim to have investigated
the effect of wind on leaves without hav-
ing looked at the quaking of aspens. Very
slight breezes are sufficient to set every
leaf on these trees fluttering in a manner
that catches both the eye and the ear of an
observer. What functional significance
might this have? I had easy access to a
white poplar (in the same genus as the
aspen) whose leaves flutter similarly; nat-
urally, I tested both individual leaves and
clusters. Individual leaves, small and
fairly stiff, didn't reconfigure in any partic-
ularly striking way. But they spun rapidly
on their stems, first one way and then the
other, without any sign that the stems were
being damaged by the continuous twisting
motion. Of some relevance in light of the
exposed habitats common for aspen, only
the white poplar leaves resisted tearing at
the highest speed I could make, about sev-
enty miles per hour. In clusters, they
clumped especially well, with leaves
pressed tightly against one another.

Based mainly on the particularly tight
and orderly conical clumping, my best
guess is that quaking in aspen has no spe-
cific function—at least at the speeds at
which it is noticed. For broad-leafed trees,
aspens are certainly tolerant of especially
high winds, both in their normal habitat
and in the laboratory. I think quaking in
light wind is just another form of the insta-
bility inherent in leaves designed for low
drag in high winds. (The leaves that roll
into cones also lose their skyward orienta-
tion at relatively low speeds.)

Both the low-speed quaking and the
high-speed reconfiguration of the poplar
genus is mainly a consequence of the pe-
culiar structure of the leaf stems. Instead
of being round in cross section, the stems
are flattened on the sides, rather like the
joists under a floor. Such structures resist
downward forces quite well, so neither
floor nor leaf blade sags. But they are not
especially resistant to sideways forces, and
thus the leaf can flutter back and forth eas-
ily. Similarly, the stem's shape isn't very
resistant to twisting, or torsional, forces—
and the ability to twist appears to be criti-
cal to reconfiguration.

The shape of leaf stems may be impor-
tant in other tree species as well. From a
biomechanical perspective, a leaf's stem
has two distinct, indeed almost antagonis-

Maple leaves fluttering in the wind
Gary Braasch



tic, tasks. It must resist bending, especially in the up and down direction, so the leaf doesn't sag. It must also permit twisting, so individual leaves can form drag-minimizing clusters in high winds. The flatness of poplar stems turns out to be one way these requirements can be reconciled. Gently twist and bend a soda straw—it resists both actions. Then slit it lengthwise—the slit straw is almost as resistant to bending, especially if the slit is on the convex side of the bend. Twisting it, however, has become vastly easier. (To use a little engineering terminology, lengthwise grooves decrease torsional stiffness with little change in flexural stiffness.) And the best place for such a groove is on the side normally stretched—the upper side in a gravitationally loaded cantilever beam such as a stem.

Indeed, grooves are found on many stems, and they do face upward. But they seem to be more common on short and broad stems. This is entirely reasonable, since a long stem needs to twist less per unit length, stretching and distorting its outer layer very little. In contrast, the twisting of a short, fat stem will subject its surface to more substantial strains; a groove can provide the specialized "shear line" to accommodate that strain.

Occasionally I've encountered leaves that tore prematurely or failed to fit nicely against their neighbors. More often than not, such leaves had insect damage. Depending on which part of a leaf an insect chooses to munch, the leaf's ability to reconfigure in high winds may or may not be affected. If a species of insect were to ask me where it's safe to chew without increasing the chances of the host tree's blowing over, I could now provide the answer. It's better to chew the parts of the leaf farthest from the stem, avoiding any flared bases. Whether some insects have adjusted their eating patterns or whether trees have tailored their patterns of unpalatability accordingly remains to be investigated. One attraction of questions such as these is that they should be answerable without expensive equipment or trips far from my own backyard. □



The Lawn of a New Day

by Bret Wallach

Here are two books, very similar in their message. Both want us to shrink our lawns, plant more trees and shrubs, lean to native species, and use a lot less of those bottles and bags piled up in the part of garden-supply shops where you hold your breath.

There the similarities of the two books come to an end. To be blunt, Stein's is the one worth reading. I will go further and invite skepticism by saying that it's hard to read this book without hearing echoes of *Walden, A Sand County Almanac,* and *Silent Spring*. *Noah's Garden* possesses the finest traits of those books—Thoreau's mysticism, Leopold's ascetic delight in things like sawdust and seaweed, and Carson's controlled anger. Stein's book can sit on the same shelf with those classics, and nobody should feel uncomfortable.

Commercially, too, *Noah's Garden* ought to do well. Like a lot of books that have succeeded in recent years, it is a combination of personal narrative and analysis. (There's something in that blend that appeals first to our impatience and then, more deeply, to our desire for meaning and our simultaneous suspicion of pure argument.) The narrative recounts Stein's experience landscaping the six acres of downstate New York on which she lives, bringing ecological principles to horticulture, and fusing "the ways of plants and the ways of gardeners."

It's a tall order because, as she says, "we have wrought in our time a calamity of habitat destruction." Even the American yard—forget the forest and farm—stands as a "terribly impoverished ecosystem," only one step removed from that ultimately destructive landscape called th golf course. There, Stein says, we create " hole in the world" and think it beautiful.

Mercifully, Stein lords it over no one; i fact her book can be read almost as a cor fession, an account of all the things she di wrong:

> We cleared brush and pulled vines an hauled rocks and broke ground and du beds until, after years of high hopes an hard work, we had an expanse of lanc scaped grounds and gardens that seemed t us like Eden. Then it hit. I realized in an ir

NOAH'S GARDEN: RESTORING THE ECOL OGY OF OUR OWN BACK YARDS, by Sar Stein. *Houghton Mifflin Company $21.95; 294 pp., illus.* REDESIGNING TH AMERICAN LAWN: A SEARCH FOR ENV RONMENTAL HARMONY, by F. Herbert Bor mann, Diana Balmori, and Gordon T Geballe. *Yale University Press, $19.95 166 pp., illus.*

stant the full extent of what we had done: w had banished the animals from this paradis of ours.

All she had done, of course, was creat the garden that so many of us strive for, place with a "deadly still" lawn, that "per fect sealant through which nothing els can grow," a place where "not even a hor eybee could find a flower to sip." Fro that moment of realization onward, Stein design principle changed. She became de termined to "reconnect as many plant an animal species" as she could and to weav her garden—and the gardens of as man of us as she can convert—"into somethin big enough to matter."

The essential design principle she advo cates is simple: corners with trees an shrubs, preferably native, edged by berr



Lawns in suburban New Jersey
Barrie Rokeach; The Image Bank

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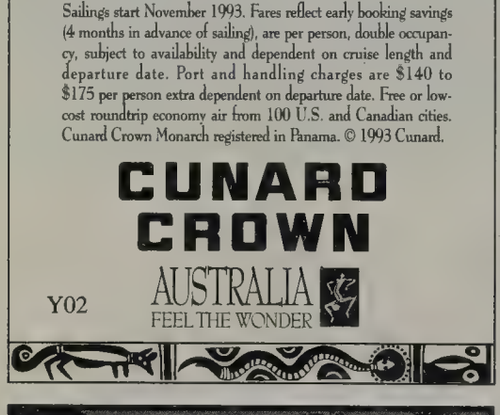
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bushes and merging, near the house, into native grass and wildflowers, minimally mown. The plant choices, on the other hand, are immense, for as she says with a dose of antianthropocentrism, "The number of seeds we plant are a spoonful compared to the oceans of seeds planted by other animals." What we do plant, she continues, should meet the seasonal dietary requirements of the native animals—as many of those animals as possible, and not just mammalian or avian—and it should do so chiefly with plant species native to the region. There should be, in other words, no single American garden, but many.

I cannot imagine many of Stein's readers disagreeing with her general orientation or with her particular criticism of pesticides. (She is especially good at desanctifying biological controls, and she is as barbed as some of her plants when she goes after the marketers of these not-so-selective remedies and their catalogs "printed on recyclable newsprint with vegetable-based ink.") She has some good criticism of forest-practice ordinances, too, which she argues are well-meaning but fail to protect growing stock: "Sooner or later it [the big tree we protect] will topple [and here comes another Steinian barb] onto its bed of pachysandra."

Some readers will wonder about bugs and snakes and spiders, but Stein is undogmatic, using sprays on occasion and advocating professional hunters to thin her locally soaring deer population. Other readers, particularly in the Midwest, may wonder, as Stein does not, about the effect of so much prairie grass upon the health allergy sufferers.

My own criticisms? Stein warns us t her arithmetic is poor, but she and her e tors still need to get miles and kilomet straight. And to say that Seattle, w thirty-nine inches of precipitation an ally, is in a "rain forest area" is misleadi My eyebrows rise when she reports m ter-of-factly that cereal agriculture beg 10,000 years ago in the Jordan River v ley because the climate grew drier. F there's something else that's not a quibb her attempt to be programmatic.

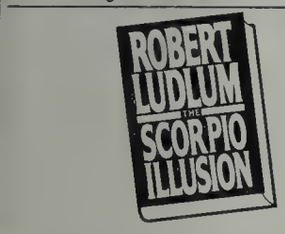
Stein or somebody decided that s needed to defend her way of gardeni against those readers ready to dismiss it naïve and unrealistic. So she writes abo how much money we will save, and s even predicts (it is the one snobbish pat in the book) how other people will foll once the new style takes hold. She spea of the practical importance of ecology, "sophisticated ecosystem services." S stays away from the word *beauty* though it were the plague, even thou you cannot read a chapter without feeli her love for the garden she's made. S lies through her teeth when she says, "I neither a romantic nor an altruist."

This strategy is a terrible mistake, par because it's so completely disingenuo When we argue that our backyards mat much to the health of the global biota, are pushing the facts. People who have sense of the size of this country may b the argument, but I don't, and Stein hers doesn't. (At one point, she admits th restoring ecosystems "is not a backya



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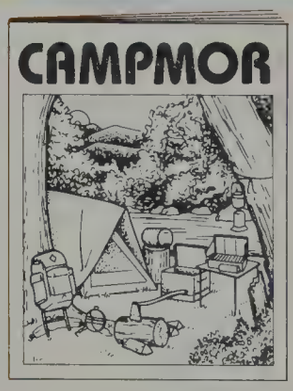
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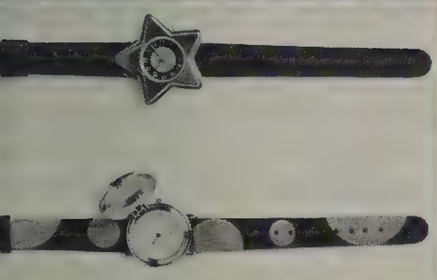
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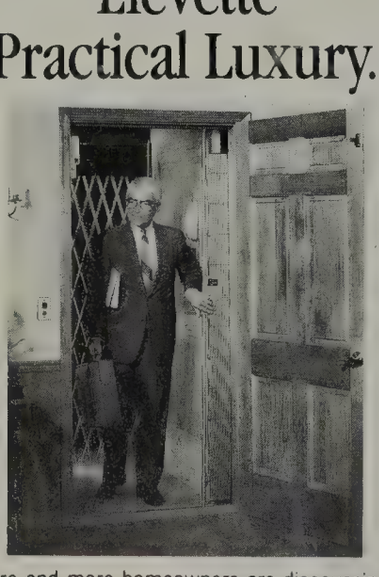


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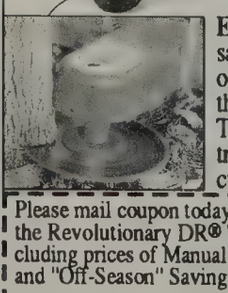
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job," but that's when she's not in her pr
grammatic mode.) So why rest the ca
chiefly on the ecological rock?

The answer is that Stein—and she h
lots of company here—wants to appe
tough, hard-nosed, or (God save us) pra
matic. She wants to win, and she thin
that hard science is the best way to do it
a hard world.

This is dishonest or at least self-decei
ing. I recall H. L. Mencken's essay "T
Libido for the Ugly," and I think of t
cultural landscapes—urban and rural-
that we are butchering without a thoug
for the beauty we are destroying. Wh
people like Stein—the people with ey
that see—shy from the word *beauty,* wh
can the rest of us think? When they nev
fight in the name of beauty, what can t
rest of us *not* think? We will naturally co
clude that aesthetics are unimporta
alongside "ecology."

Redesigning the American Lawn a
tacks the biotic equivalent of Astroturf, t
"industrial lawn." Of course, it's the law
that millions of us wish we had—lawn
an even height, even color, and a selecti
of grasses culled more stringently than t
Herrenvolk. Perhaps the shrewdest obse
vation in the whole book is that this law

has the added virtue, at least in terms of t
lawn care industry, of never being co
pletely attainable. There is always so
new and necessary bit of technology, so
new finding on fertilizers, some modific
tion of pesticides or new variety of grass
quired to move toward the ideal, or, in mo
competitive terms, to keep up with t
neighbors.

Sounds a lot like what's happened to o
perception of our own bodies, which a
never quite as fatless as we've been pe
suaded they should be.

The third and best chapter of the boo
discusses the industry that has grown up
serve (or is "service" the better word?) t
25-million acres of turf that apparent
exist in this country. Eighty percent of th
turf is made up of some 58 million yard
nearly a tenth of which, by acreage,
maintained by 5,500 lawn-care comp
nies. Most of them belong to the Profe
sional Lawn Care Association of Ameri
and employ "professionals" who eager
await each new issue of the peculiarly, a
perhaps even significantly, named *Amer
can Lawn Applicator.* Today, the Unite
States annually manufactures nearly
billion worth of lawn and garden equi
ment and sells some $700 million worth
pesticides for use on lawns. In addition,

ı of the fertilizer industry's profits
ıe from lawn care.
Ve don't learn anything about specific
ıpanies, apart from a tidbit about the
ıamed company responsible for the
y effective national "campaign against
ver in the lawn." The authors' primary
:rest is not in muckraking but in waking
up to the ecological consequences of
· lawns: to the direct and indirect im-
:ts those lawns have on the nation's en-
y consumption, its air and water qual-
its water supply, and its biodiversity.
leed, the authors are so determined to
rm us that they verge more than once
o dramatic irrelevancies like the deple-
n of the Ogallala aquifer.
The book, in short, is another environ-
ental critique that bases itself on science,
t aesthetics. But the weaknesses in this
se run deeper, for this is the work of
ee "author-instructors" from the Yale
hool of Forestry and Environmental
udies, eleven graduate students who
gned up for a seminar on the American
vn, and a historian-librarian who played
me kind of supporting role. The students
med teams to write each of the chap-
s, which were later revised and "sub-
ıntially rewritten" by the author-instruc-
tors. Perhaps the seminar participants learned a lot, but not even the luster of their Yaleness can save this book from being a Class Project.

The first sentence of the book—"The lawn holds an important place in the American view of an ideal life"—is bad enough, but the authors go on to inform us that "today science accepts the existence of a chemical basis for life," and that "before launching on a course of action, it is important to assess what you want to gain." Underlying all these sentences is the subtextual apology: "I know it's bad, but this was due on Tuesday morning, and my 'author-instructor' didn't have the heart to do more than fix my worst bits."

Unfortunately, one very good thing in this book, the name Freedom Lawn, is likely to be passed over simply because the book, as a book, is such a dog. The authors suggest that we might wish to eliminate or reduce our lawns. Alternatively, we might change the way we manage them, perhaps by shifting to different grasses or, better yet, by permitting "all kinds of plants to exist in the only way they know how—by growing." This sentence threw me at first, but it turns out that the authors are only urging me to keep doing what I'm already doing: tending a patchful of whatever survives mowing.

But now this patch of green—and even its occasional brown bit—has a name. And what could be better than the name Freedom Lawn? The authors—I would give credit if I knew who deserved it—contrast this thing I've always been ashamed of with the Industrial Lawn that I, like all upright Americans, have craved as much and as hopelessly as I've wanted a fatless body. And now I'm told that my lawn—so rich in dandelions and clover—is OK: it saves energy; reduces the need for deadly chemicals, fertilizer, and water; even preserves the biota. True, I don't appreciate being told to "remember that your lawn is your property, your little piece of the biosphere." But Freedom Lawn I can use. I'm through feeling guilty. The next time I pass my neighbor's perfect body (sorry, I mean lawn), I shall try hard to wear my superiority lightly.

Bret Wallach teaches at the University of Oklahoma. He is the author of At Odds with Progress: Americans and Conservation *and of the forthcoming* Side Effect: Rural Development and the Desecration of the Oriental Landscape.

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DEADLINES:

November 1993, *September 1;* **December 1993,** *October 1;* **January 1994,** *November 1*

A Book to Steer By

by Gail S. Cleere

According to the *Astronomical Almanac,* published by the U. S. Naval Observatory, the autumnal equinox occurs at 8:22 P.M., EDT, on September 22. Astronomer Bob Berman describes it as an "orchestral pause...when both poles of Earth tilt neither toward nor away from the Sun, producing a worldwide symmetry of sunlight and darkness." At the autumnal equinox, the sun crosses the celestial equator heading south.

This type of information—dates and times of equinoxes and solstices and the changing of the seasons—has traditionally been found in almanacs. In one form or another, almanacs have been around ever since humans began to organize time into units larger than a single day. Perhaps the earliest surviving almanacs are recorded on mammoth bones, dating back some 30,000 years to the last Ice Age. These markings have been interpreted by Alexander Marshack, a research fellow at Harvard's Peabody Museum, as a daily tabulation of the phases of the moon. Why did ancient people care? Because they wanted to plan ahead for migrations and hunting. They wanted to foretell the future and establish rituals to appease the gods. Perhaps they were trying to make sense of the mysterious forces of nature.

The first written almanacs are the eighth century B.C. Babylonian tablets that list such astronomical events as solstices and equinoxes, moon phases, and eclipses. In Europe, the earliest printed almanacs appeared in the fifteenth century, when voyages of exploration demanded tables from astronomers that would help in navigation.

With the invention of movable type, almanacs became common and affordable, and most importantly, they could be reproduced without accumulating scribal errors. These common almanacs were divided into an ecclesiastical tabulation of days, weeks, and months; annotated with feasts, fasts, and festivals; and sprinkled liberally with astronomy and astrology. As time went on they included configurations of the sun, moon, and stars with the earth; phases of the moon; dates of solstices and equinoxes; transits of planets; weather predictions; superstitions; farming hints; and other "useful" information.

The *Seaman's Kalendar,* published in England by John Tapp in 1600, was perhaps the first reliable almanac published for mariners. The *Connaissance des Temps,* published in 1679 in France, was the first national almanac, and it has been published annually to this day. Great Britain's *Nautical Almanac* was first published in 1767, and was used by mariners in the colonies. After the Revolution, this dependence did not change. Although many popular almanacs (such as Ben Franklin's *Poor Richard's Almanac*) were published by Americans, only the established foreign almanacs were trusted for scientific and navigational use.

In 1852, the United States government published the *American Ephemeris and Nautical Almanac for 1855*, its first almanac for use by surveyors and astronomers, and the *American Nautical Almanac* for mariners. They were a demonstration to the rest of the world of the new nation's scientific prowess. But there were problems. To begin with, the formulas traditionally used to calculate lunar and planetary positions were far from perfect. Isaac Newton had formulated his laws of gravitation nearly two centuries before, but the mathematical problems that accompanied them were still far from solved. For example, the moon's calculated position still did not match actual observations. Formulas laboriously developed fifty years earlier by Europeans needed to be upgraded.

During the following decades, Simon Newcomb and other mathematicians at the Nautical Almanac Office worked on new formulas for calculating the orbits of the moon, Mercury, Venus, Earth, Mars, Uranus, and Neptune. Meanwhile, George Hill, a shy and retiring mathematician hired by Newcomb, worked alone on the theories of the most difficult planetary orbits—those of Jupiter and Saturn. By the turn of the century, Newcomb and Hill had come up with new formulas for calculating the orbits of all the known planets. These were accurate enough to be used until 1960, and in the case of Mercury, Venus, Earth, and Mars, until 1984. Hill's independent work on the moon's orbit introduced theoretical ideas that would inspire the most recent refinements to the formulas.

The U. S. government almanacs are now the authority for astronomical and navigational data in this country. By international agreement, the task of computing and publishing the information is shared with, among others, the Royal Greenwich Observatory in Britain, the Bureau des Longitudes in France, the Astronomische Reichen-Institut in Germany, and the Institute of Theoretical Astronomy in Russia. Suffice it to say that the date and time given in the *Astronomical Almanac* for autumn's start is acceptable the world over.

THE PLANETS IN SEPTEMBER

Mercury emerges from behind the sun but cannot be seen this month from northern latitudes.

Venus is a brilliant morning object, rising in the eastern sky three hours before the sun at the beginning of the month. On the 21st, Venus will pass less than half a degree above the star Regulus in Leo. Venus, shining at magnitude –4, will appear 147 times brighter than the +1.4 magnitude Regulus.

Mars remains in Virgo. Look for it very low in the west–southwest about an hour after the sun sets. On the evening of the 6th, use the much brighter Jupiter as a "pointer" to Mars, which is barely a degree to the south. On the evenings of the 15th and 16th, Mars passes about 2 degrees to the north of the star Spica, and on the evening of the 17th, a very thin crescent moon passes below Mars and Spica. By midmonth, however, the bright solar glare may make it nearly impossible to see Mars as evening twilight swallows it up. Last month the *Mars Observer* spacecraft reached that planet, where it will orbit 234 miles above the surface in a polar orbit. In the next two years we should learn a great

more about volcanoes, channels, and
r icecaps on Mars.

upiter is also in Virgo, rapidly moving
ard the other side of the sun. Look for
planet low in the west at sunset. A few
nds join it (see Mars, above) during the
th. The big news for Jupiter was an-
nced in June by the International As-
omical Union: the recently discovered
net Shoemaker-Levy is on a collision
rse with Jupiter and is expected to
e the planet sometime next July. An
nt like this has never before been pre-
ed.

aturn remains the jewel of our late
mer nighttime sky. Now among the
t stars of Capricornus, this ringed
net rises about an hour before sundown
stays with us for most of the night.
ch the nearly full moon approach Sat-
from the west during the night of the
n. The moon will pass 7 degrees above
urn on the 27th.

Uranus and **Neptune** are only a hair's
adth away from each other in eastern
ittarius and can be seen well up in the
th along your meridian as night skies
ken. Very, very dark skies will reveal
nus to the naked eye (magnitude +5.7),
Neptune requires use of binoculars or
elescope (magnitude +7.0). From the
h through the 28th, Neptune hovers
than a degree north of Uranus. This is
only opportunity during our lifetime to
both of the planets in the same, moder-
power telescope field of view; a × 60
piece will show both planets at once.

Pluto is up during early evening hours
September, but sets by about 10:30 P.M.
The **Moon** reaches last quarter on the
at 2:26 A.M., EDT; is new on the 15th
1:10 P.M., EDT; reaches first quarter at
2 P.M., EDT, on the 22d; and is full on
30th at 2:54 P.M., EDT.

*il S. Cleere writes on popular astron-
y and is a founding member of the
ernational Dark Sky Association, an
ganization dedicated to preserving the
rkness of the night skies for astronomi-
observation.*

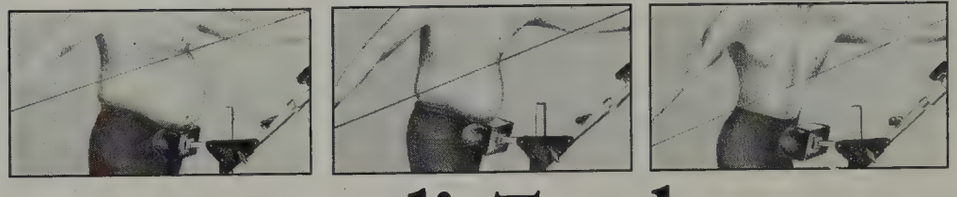


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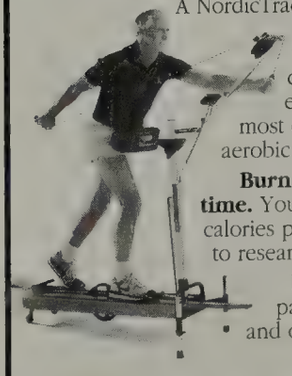
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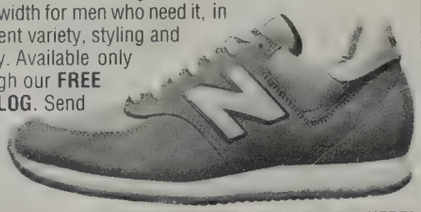
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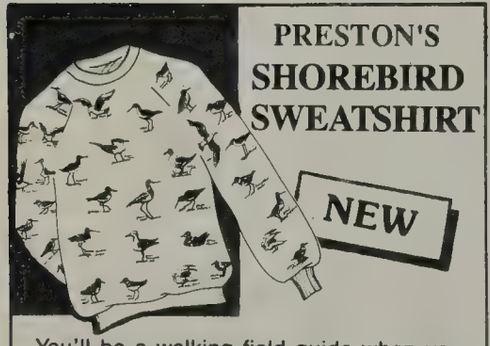
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At the American Museum of Natural History

Man and Nature Lectures

As a young man, Charles Darwin first attempted to design a model for the earth based on his "conviction that some great law of nature remains to be discovered by geologists." Darwin's later interests revolved around his growing belief that the origin and development of species had arisen by natural selection driving evolution. In this year's Mack Lipkin Man and Nature Lectures, to be held at the American Museum of Natural History on Monday and Tuesday, October 25 and 26, Frank H. T. Rhodes, president of Cornell University, will discuss Darwin's career. A geologist by training, Rhodes was appointed in 1987 to the National Science Board by President Reagan, and in 1989 to the President's Education Policy Advisory Committee by President Bush. Rhodes is the author of more than seventy major scientific articles and monographs and sixty articles on education; his books include *The Evolution of Life; Fossils;* and *Language of the Earth.* Both lectures will begin at 7:00 P.M. in the Main Auditorium. Advance admission for the two-evening series costs $20 ($10 for members) and may be ordered from the Office of Special Events, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024-5192. Call (212) 769-5019 for further information.

Stanford White's New York

The work of architect Stanford White (1853-1906) represents the peak of Beaux Arts elegance in late nineteenth century New York. On Wednesday, September 8, at 7:00 P.M. in the Kaufmann Theater, architectural historian David Garrard Lowe will lecture on White's life and career, which ended dramatically with his murder. After the lecture, Lowe will autograph copies of his book, *Stanford White's New York.* Call (212) 769-5606 for more information.

The Biodiversity of Cuba

In a joint project of the American Museum of Natural History and the Museo Nacional de Historia Natural in Havana, Cuba, scientists have been documenting Cuba's biodiversity since 1989. The bilingual exhibition, "Cuba: Nature of an Island," will feature some of the finds and photographs from the project, including fossils of a 16-million-year-old sloth—to date the earliest skeletal evidence of a land mammal in the West Indies. Opening Friday, September 17, in the Akeley Gallery, the exhibition will run through Monday, January 3, 1994, and will then be on permanent display in Havana's Museo Nacional de Historia Natural.

Biosphere 2: The Human Experiment

A 3.15-acre, greenhouselike structure near Tucson, Arizona, Biosphere 2 contains a rain forest, a miniature ocean with a coral reef, a marsh, and 3,800 plant and animal species. Eight scientists and engineers have been sealed up inside this self-sustaining ecosystem since September 1991, and they will reemerge this month. John Allen, the vice president of Biospheric Development for Space Biospheres Ventures, will talk about the project in a slide- and video-illustrated program on Wednesday, September 1, at 7:00 P.M. in the Kaufmann Theater. For ticket availability, call (212) 769-5606.

Margaret Mead Film and Video Festival

The seventeenth annual Margaret Mead festival opens on Monday, October 4, with a new documentary, *Madame l'Eau,* by Jean Rouch. In the film, Rouch and his West African friends, Lam, Damouré, and Tallou, travel with their mule to Holland to learn about applying windmill technology to their drought-ravaged fields. Sixty-one films will be shown in the course of the week-long festival. To receive a complete schedule, call (212) 769-5305.

These events take place at the American Museum of Natural History, located on Central Park West at 79th Street in New York City. The Kaufmann Theater is located in the Charles A. Dana Education Wing. The Museum has a pay-what-you-wish admission policy. For more information about the Museum, call (212) 769-5100.



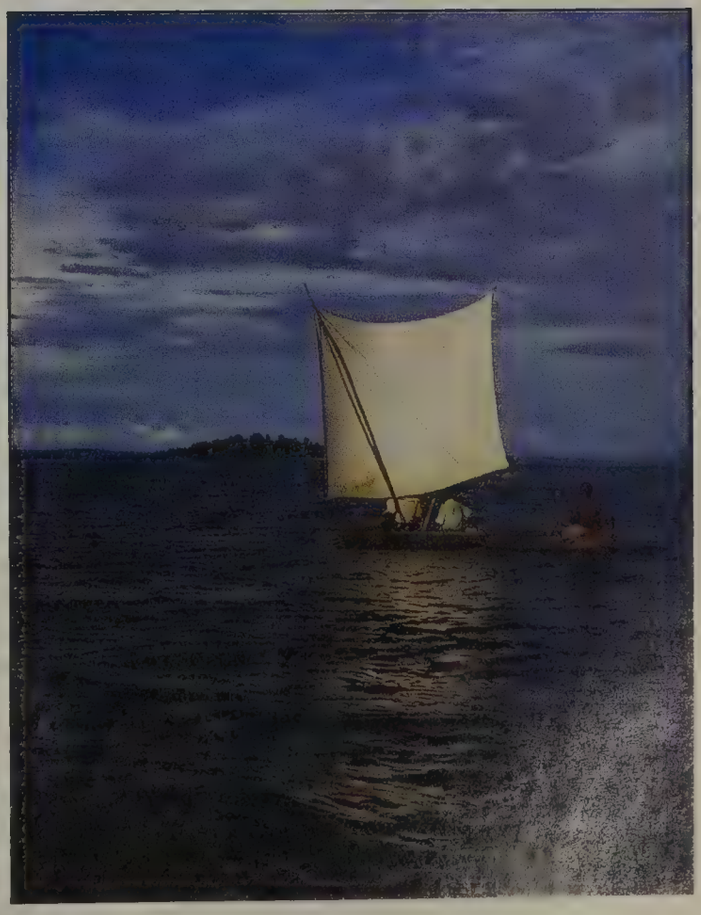
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A Fruit Freely Chosen

Rejected by the eighteenth-century slaves for whom it was intended, breadfruit didn't catch on in the Caribbean until after their emancipation

by Raymond Sokolov

Even as a child, I connected the infamous Capt. William Bligh of the mutinous ship *Bounty* with food. On television in those days, there was an ad that ran again and again during programs for kids, in which a tyrannical Bligh yelled at his first mate: "Mr. Christian, come here. I want my Post Toasties."

The same line was shouted frequently at school because we had a classmate whose last name was Christian.

Somewhat later, I must have found out the real link between Bligh and food when I read the Nordhoff and Hall novel *Mutiny on the Bounty*. But I retained only the main story line, in which a South Pacific idyll turned into a classic drama of survival on the open seas when Bligh's crew revolted and set him afloat in midocean in a small boat.

Recently, as part of my research for this magazine, I have been reminded that the *Bounty* voyage and the mutiny were, in fact, part of what might be called the epic of economic botany. Bligh had put his single-minded energies into transporting a useful plant from the Old World to the New, and his seamen grew weary of doubling as nurserymen for more than a thousand heavy tubs of *Artocarpus altilis*.

While Europe stood on the brink of universal disruption and revolt in 1789, Bligh was trying to fulfill his mission of bringing breadfruit from Tahiti to Jamaica. He was executing a plan conceived by the influential botanist Joseph Banks, who, when he traveled to the Pacific with Captain Cook, had observed firsthand how breadfruit made the happy indolence of Polynesian life possible. Banks reasoned that if this bountiful plant could be cultivated in proximity to the slave plantations of the West Indies, it would solve or at least alleviate a fundamental problem.

It would feed the slaves and eliminate or greatly reduce the need for plantation owners to give them time off from financially productive labor in sugar cane fields to work on their own vegetable gardens. From our point of view (and perhaps that of the slaves, who must have cherished the time to themselves and the subversive market economy that gardening offered them), the Banks plan looks diabolical. But a just destiny determined its ultimate fortunes, human and horticultural.

Right off, the pendulum swung away from Banks: the mutineers threw the breadfruit overboard. But Bligh survived his 4,000-mile lifeboat ordeal, sailed back to Tahiti, and after possibly mitigating his management style, did finally land in Jamaica in 1793 at the helm of the *Providence,* whose decks looked like forests.

Most of Bligh's troubles had been caused, at the most fundamental level, not by human nature per se, but by human tampering with nature. *A. altilis,* as Bligh and Banks found it under cultivation in Polynesia, was a seedless plant. At some point in its travels from its birthplace in the Malay Archipelago, perhaps many times, the breadfruit was cloned from the rootstock of specially desirable seedless trees. So Bligh couldn't just collect a lot of seeds and sail away. He had to take whole trees, trees so sensitive to cold that they had to be dragged belowdecks at night until they reached sultry safety in tropical America.

Even then, the Banks plan continued to misfire. Slaves refused to eat breadfruit...until they were freed. That, at least, is the legend that has come down to us. And the story is so appealing, we may as well accept it and not go looking for alternative explanations (for example, that may have taken a while for the Bligh tre to fruit in quantity in their new home, a that the odd taste of breadfruit, of whi more later, may have taken a generation two to catch on).

Between the end of slavery in t British Empire (1838) and now, howev breadfruit has established itself firmly the cuisines of the Caribbean. In certain lands, affection for these large (six poun green, spherical fruits, with their pustu rinds and smooth white pulp, runs ve deep, perhaps nowhere more so than Saint Vincent, a lush volcanic island w of Barbados.

Since 1979, Saint Vincent and thir two sister islands have been a fully ind pendent Commonwealth nation known Saint Vincent and the Grenadines. Wh the local economy is heavily dependent the export of bananas, Vincentians lo breadfruit with an unashamed passion discovered this first in conversation wit woman health worker in New York. At t time, I was routinely asking Caribbe émigrés about breadfruit. Some express only routine interest. This woman, wh nationality I didn't know, lit up imme ately and recommended steaming brea fruit and serving it with kingfish. Yes, t was really delicious, and she hoped friend of hers would be bringing so with her on the plane from Kingstown (n Kingston but Kingstown, the capital Saint Vincent).

At the shop in the Kingstown airport, shirts emblazoned with breadfruit are sale. Where the cab turns on to the hig way, a tall tree towers; from it dang dozens of green orbs. I assume that soo

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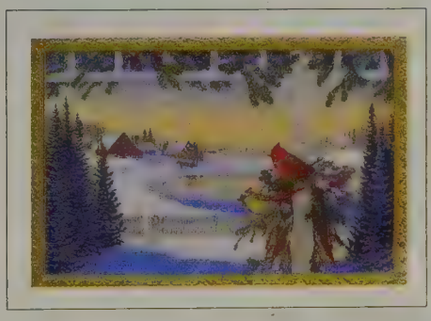
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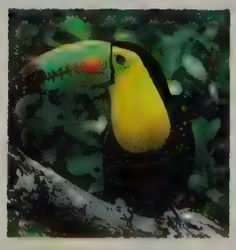
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will be tasting the fruit itself in one of the myriad cooked forms that I have been reading about. But it is nowhere to be found. Not in markets or on menus. I keep missing it here and there. It is always sold out before I get there or out of reach on trees, such as the big clone of a tree brought over by Bligh that is the main attraction of the botanical gardens high above the city center.

The national dish, I am told, is buljol (a salt cod salad served on many islands) with breadfruit. One restaurant promises the dish but has to substitute eddoes (a potatolike taro) for breadfruit.

I am ready to start climbing trees to get my own fruit, but I haven't a clue how to pick one that's ripe. (It turns out that different recipes call for different degrees of ripeness, from green and hard to mottled and soft. In the U. S. Northeast, breadfruit is available unpredictably in Caribbean markets, stored in tubs of water.) At last, on the way to our flight home from the Kingstown airport, we pass a roadside stand selling whole fruit completely blackened from charcoal baking. The vendor peels one, revealing the creamy, tan flesh inside. He removes the fibrous "gut" from the center and makes it clear that it is time to eat.

It tasted like…bread. White bread of the spongy variety. An acquired taste and not one I am going to work hard acquiring. Perhaps I'd like it with a sauce or deep-fried like French fries (green breadfruit is said to resemble the texture of potatoes). Polynesians allegedly flavor bland green breadfruit with mushy, pungent, very ripe fermented breadfruit. Are they aware that the fermentation provides a significant amount of vitamin C, just as it does for fermented cabbage (sauerkraut)? European sailors discovered that breadfruit consumption lowered the rate of scurvy on long voyages. Breadfruit also comes off relatively well as a source of protein (1.3 grams per 100 grams), warding off khwashiorkor among Polynesian children.

Like any staple food, breadfruit has inspired a large variety of recipes. The hard, green fruit can be treated like a potato—baked, boiled, or mashed. Cubed, it takes about twenty-five minutes to boil until chewable but still crunchy. To reach a stage soft enough to purée, count on at least thirty-five minutes.

In Polynesia, the primordial method of cooking breadfruit is in a pit, with heated stones, in other words, a luau. I had breadfruit this way in New Zealand, at Rotorua, where the heat came from geothermal steam geysers. The culinary result wa Polynesian, very bland and pasty.

Is the charbroiled breadfruit I had o Saint Vincent a Polynesian survival, transfer of an African method to an exoti fruit, or a spontaneous development on th island? It is hard to know, but there is n doubt about the originality of the Jamaica dish that combines Pacific breadfruit wit the African fruit called ackee and with sa cod introduced from Europe. It migh

Stuffed Breadfruit

(Adapted from *Traditional Jamaican Cookery,* by Norma Benghiat, Penguin, 1985)

24 completely ripe ackees in pods, with black seeds and yellow fruit visible (unripe ackee is toxic)
½ pound salt cod
2 tablespoons butter
¼ cup oil
2 onions peeled and sliced
1 sprig thyme
3–4 slices hot chili Pepper
1 unripe breadfruit, full but not soft

1. Remove ackee from pods. Discard seeds and the pink membrane in the cleft of each fruit.
2. Wash and combine with the cod in a large quantity of boiling water. As soon as the ackee is tender, drain fruit and fish in a colander. Separate ackee from fish and, after cleaning skin and bones, flake the fish.
3. Heat butter and oil in a skillet. Add onions, thyme, and chili. When onions are translucent, add fish and ackee. Stir for a few minutes, trying not to crush the ackee.
4. Cut a slice off the top (stem end) of the breadfruit. Scoop out the core of the fruit and just enough of the flesh so the fish and ackee mixture will fit inside it.
5. Stuff breadfruit with fish and ackee mixture. Replace the slice from the top of the breadfruit. Roast over an open fire until outside is completely blackened and a trussing needle pushed into the breadfruit penetrates easily, or bake in a 350-degree oven for a half hour or until tender.
6. Peel the fruit before serving. (Alternatively, and perhaps more practically, roast the breadfruit whole, peel and core while hot, and stuff with hot salt cod and ackee mixture.)

Yield: 4 servings

ve as an emblem for the complexity of ibbean culture. And no one would say as dull in terms of taste.

n the French islands, the breadfruit has spurred cooks to rise to a difficult oc- ion. The fruit was introduced to Guade- pe in 1793 from Santo Domingo (I fol- data provided by Andre Negre in *illes et Guyane à Travers Leur Cui- e*). In 1820 fruit abounded, but a onel Boyer-Peyreleau curled his lip predicted that breadfruit would never y a part in human nutrition.

Nevertheless, Creole cooks on the nch island adapted *fruit à pain* to many their own recipes. For example, they ed together eggs and puréed breadfruit deep-fried it as *acras,* fritters de- nded from an African original first de with black-eyed pea flour and still n on the streets of Lagos (*akara*) and in theast Brazil (*acaraje*). There is a crab breadfruit *colombo,* a curry adapted m recipes of East Indian laborers ught to the islands in the nineteenth tury. (Actually, the name *colombo* may icate a connection with the capital of former Ceylon—now Sri Lanka—ner than with coolies, as Dr. Negre sug- ts. In any case, the French islanders er to their conventional prepared com- rcial curry powder as *poudre de ombo*. And Dr. Negre is happy to claim s a national dish.)

In other stewlike preparations with al- gedly Carib names (*migan, matété*), adfruit serves as a creamy thickener or nore solid, potatolike starch.

As I type these words, my interest in adfruit revives. Perhaps Negre is right a crab-breadfruit *matété* is a splendid h. Still, I do not expect to see breadfruit, s unexpected first cousin of the fig, mul- rry, and Osage orange (all members of Moraceae family), become the next fad it. To paraphrase Secretary of the Trea- ry Bentsen, the breadfruit is no kiwi.

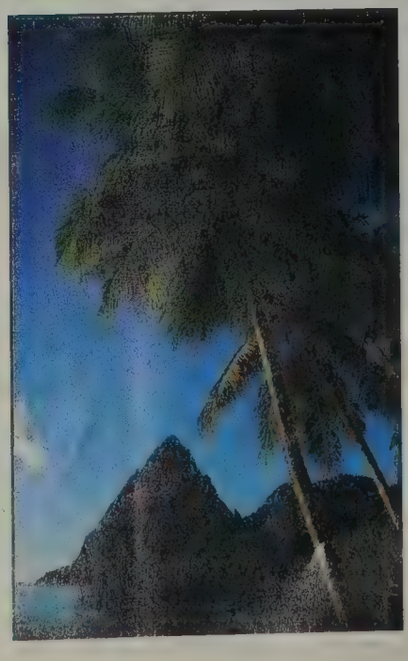
And yet I take heart from the real suc- ss of *A. altilis* in its intended New World me. Islanders chose it freely and only er they had free choice. There is also me comfort in knowing that Banks and igh did not undermine the system of ve gardening that, as scholars Sidney intz and Lydia Pulsipher have shown, as a crucial outlet for African initiative d survival, both literal and cultural, be- re emancipation.

aymond Sokolov is a writer whose spe- al interests are the history and prepara- on of food.



SAILING THE CARIBBEAN ABOARD THE LEGENDARY *SEA CLOUD* February 15-24, 1994

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hooklet to attach and for burdock seeds to spread. A hooklet's hold is tenacious, whether on a hair, a fiber, or a feather.

This burdock, in a field in Michigan, may have been a tempting perch to a passing golden-crowned kinglet. When the photographer spotted this scene on an early winter morning, the kinglet, too, was dead and dried, and seemed to him like "a butterfly caught in a web."—*J. R.*

Photograph by
Skip Moody
Dembinsky Photo Associates



Memento Mori

Sprouting with weedy vigor, burdock grows tall in summer. Its tiny purple or pink flowers, which jut from prickly globes, may slightly soften the used-up landscapes—old fields and edges of abandoned buildings—where this wildflower thrives. But by late fall the brittle, leggy stalks and dried burs are stark sculptures in such waste places. The naked bur that surrounded the fruit reveals its now dry, but still effective, bristles.

In the normal course of things, these hooklets are instruments

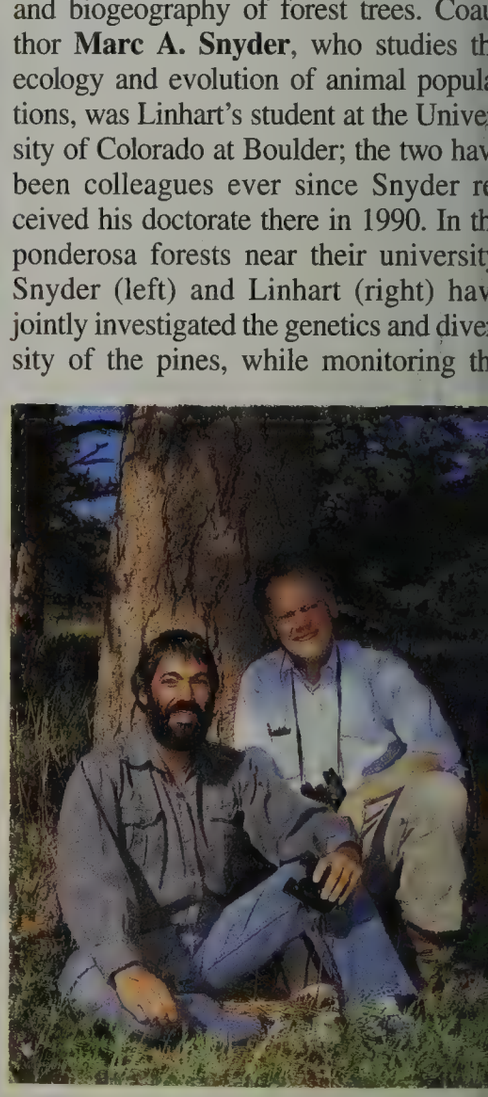
Randy Thornhill (page 30) says his enthusiasm for biology began in childhood, when he was an avid insect collector and bird watcher. His interest in more theoretical matters dates to his years as a graduate student at the University of Michigan, where he earned his Ph.D. in evolutionary biology. Currently, Thornhill is a professor of biology—and self-professed people watcher—at the University of New Mexico at Albuquerque. His research projects include investigations into animal (including human) sexual behavior and the mechanisms (such as psychological adaptations) that control it. As part of these investigations, he hopes to tease apart some of the components of human beauty and, by interpreting them in light of the theory of sexual selection, gain a greater understanding of beauty's powerful allure. For a general treatment of the sexual behavior of insects, readers can turn to *The Evolution of Insect Mating Systems* (Cambridge: Harvard University Press, 1985), which he coauthored with John Alcock. A good introduction to symmetry and its importance can be found in "Fluctuating Asymmetry as an Indicator of Stress: Implications for Conservation Biology," a 1989 article by R. F. Leary and F. W. Allendorf in *Trends in Ecology and Evolution* (4: 214–17).





For the past four summers, **Mark Norell** (page 38), an associate curator of vertebrate paleontology at the American Museum of Natural History, has traveled to the Gobi Desert of Mongolia in hopes of finding fossils that shed light on the evolution of reptiles, dinosaurs, and birds. Continuing a tradition of Central Asian exploration begun by the American Museum of Natural History in the 1920s, Norell (above) and other members of the recent expeditions have excavated fossils that will help clarify the relationships among and within major groups of vertebrates. However, the discovery in 1992 of the wingless bird *Mononykus* by Norell, coauthor **Jim Clark**, and Mongolian expedition member Perle Altangerel raises questions concerning how modern birds evolved and how flight originated. Clark, a postdoctoral fellow at the American Museum, earned his doctorate from the University of Chicago. In the field, he focuses on finding smaller, often overlooked fossils from the age of dinosaurs. Coauthor **Luis Chiappe** received his doctorate from the National University in Buenos Aires and is currently a research fellow at the American Museum specializing in Mesozoic birds. More information on carnivorous dinosaurs and their avian relatives can be found in *Predatory Dinosaurs of the World: A Complete Illustrated Guide,* written and illustrated by Gregory S. Paul (New York: Touchstone Books/Simon and Schuster, 1988).

Ecologist **Yan B. Linhart** (page 44), naturalized U. S. citizen who was born i Prague, Czechoslovakia, took degrees Rutgers and Yale before gaining his do torate from the University of California Berkeley in 1972. For more than twen years he has studied the genetics, ecolog and biogeography of forest trees. Coau thor **Marc A. Snyder**, who studies th ecology and evolution of animal popula tions, was Linhart's student at the Unive sity of Colorado at Boulder; the two hav been colleagues ever since Snyder re ceived his doctorate there in 1990. In th ponderosa forests near their universit Snyder (left) and Linhart (right) hav jointly investigated the genetics and dive sity of the pines, while monitoring th



habits of squirrels and porcupines that liv among them. Their studies of the effects o Abert's squirrels on forest habitat hav been funded for the past four years by th National Science Foundation. Linhart be lieves that ecologists' perspectives can b biased by studies of short-lived species such as rats and corn, raised in cages an greenhouses. "Studying long-lived specie in the wild," he says, "expands our view o ecology and evolution. Besides, it's grea to get paid for what I love to do—ru around in the woods."

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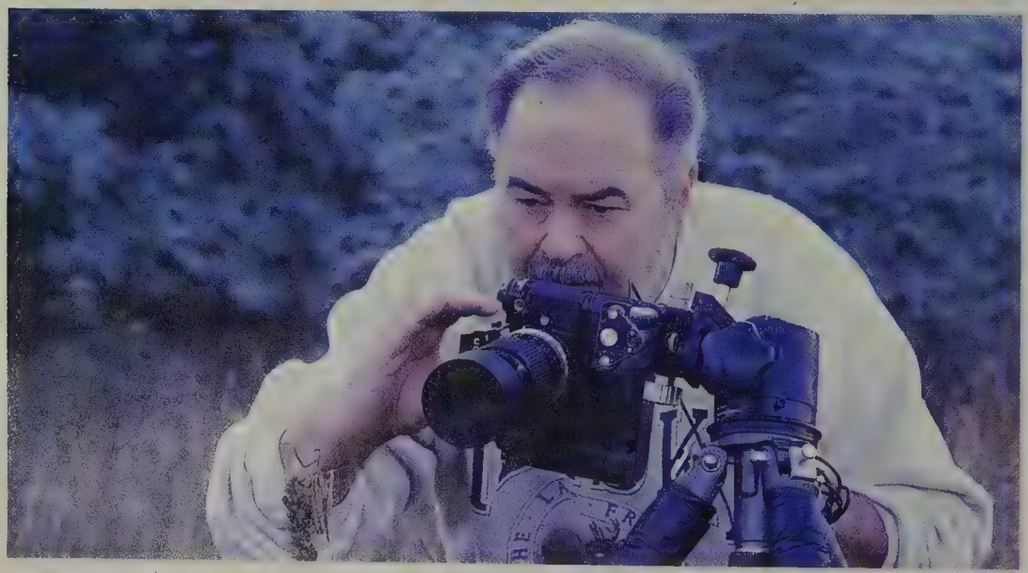
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Beginning with a stint as a Peace Corps volunteer in the Ivory Coast more than twenty-five years ago, **Daniel Stiles** (page 50) has long been concerned with environmental and developmental issues in Africa. He first encountered the Gabbra pastoralists in 1971, while a student archeological assistant at Koobi Fora, Richard Leakey's site. In 1981, Stiles (center) received his doctorate from the University of California at Berkeley for work on prehistoric cultures in eastern and southern Africa. He is now a consultant to the United Nations Environmental Programme and a research associate at the British Institute in Eastern Africa. Stiles is currently investigating hunter-gatherers in Kenya, Madagascar, India, and Indonesia, in hopes that their trade in wild forest products can be turned to advantage in saving biological and cultural diversity. For additional reading, he recommends *Millennium: Tribal Wisdom and the Modern World,* by David Maybury-Lewis (New York: Viking, 1992), and *Surviving Drought and Development: The Ariaal Rendille of Northern Kenya,* by Elliot M. Fratkin (Boulder: Westview Press, 1991).



The sight of a dead golden-crowned kinglet ensnared in burdock caught **Skip Moody** (page 80) by surprise; he found it to be one of the most interesting situations he has come across in his photographic rambles. The small bird depicted in this month's "Natural Moment" had evidently lost its struggle to free itself from the Velcrolike barbs of the plant. The owner of a commercial print shop, Moody specializes in "macro" nature photography. Some of his subjects are attracted to the wildflowers and the pond in his own backyard. A native of Michigan, Moody is president of the Greater Detroit Camera Club and the cofounder of the West Oakland Camera Club, in Milford, Michigan. To photograph the kinglet, he used a Nikon F3 and Nikon Macro 105mm lens in the natural light of midmorning.

Steven Vogel (page 58) has devote most of his career to studying the mechan ics of plants and animals that live in mov ing fluids. This interest has led him to in vestigate a variety of subjects, includin the aerodynamics of insects, the ventila tion of prairie dog burrows, fluid flow through sponges, and how squids and sca lops refill the jets they use for locomotion Vogel first became interested in leaves i the wind in the late 1960s, when he looke at how leaves heat up when exposed t sunshine in very low winds. Twenty year



later, he was looking for a research projec he could do in six weeks before fall classe started and decided to study how leave behave in very high winds—something h was surprised to find no one had done. Al though Vogel is a biologist, having earne his undergraduate degree from Tufts an his Ph.D. from Harvard, he has taugh himself the physics necessary for under standing the fluid dynamics involved i his research. Currently, Vogel is James B Duke Professor of Zoology at Duke Uni versity, where he has taught since 1966 He has written a number of popular sci ence books on biomechanics and on the circulatory system. For more information on how plants and animals are adapted to air and water currents, see Vogel's *Life in Moving Fluids: The Physical Biology of Flow* (Princeton: Princeton University Press, 1983).



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COVER: *A touch of pink camouflage is enough to hide a predatory crab spider amid milkweed blossoms. Story on page 58. Photograph by Allen Blake Sheldon.*



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58 LITTLE MURDERS *Simon D. Pollard*
The female crab spider sinks her teeth into her work.

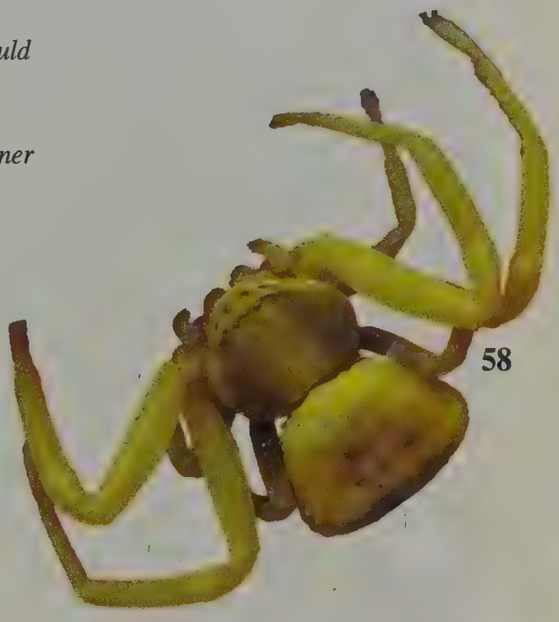
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LETTERS

LIFTING UP BABY

Loren E. Babcock's piece, "The Right and the Sinister" (July 1993), contains one statement with which I strongly disagree, although I am not a natural scientist. Babcock states that the "tendency of human females to carry their babies in their left arms (whereas men tend to carry babies in their right arms) may have deep evolutionary roots; female chimpanzees, gorillas, and orangutans also carry their babies in their left arms."

As a female with strong right-hand tendencies, I can verify the need for mothers to learn to carry their babies on the left side, leaving their right hand free to perform any number of tasks, from stirring the pot to folding the laundry. While it may feel uncomfortable at first, the discomfort is far outweighed by the need to accomplish these tasks, many of which would be impossible with the left hand. If you'll excuse my assumption that Loren Babcock is a male, that would explain why he might think that males who hold their babies on the right side do so because of "deep evolutionary roots." My guess would be that the roots are cultural, not evolutionary.

CONNIE SPIEGEL
Sherwood, Oregon

LOREN BABCOCK REPLIES: Two lines of evidence demonstrate that a left-side preference for carrying human babies is biological (not cultural) and based on a lateralization pattern that is independent of that established for other manual activities. The strong tendency for approximately 80 percent of women to carry infants in their left arms, regardless of cultural background and regardless of which hand is used for writing, stirring pots, or folding laundry, was first noted in the scientific literature many years ago (*see* article by I. Salk, *Scientific American,* May 1973). What is surprising, however, is the recent discovery (*see* report by J. T. Manning and A. T. Chamberlain in *Animal Behavior,* vol. 39, 1990) that, just like human females, female chimpanzees, gorillas, and orangutans clearly demonstrate a left-handed cradling tendency. Accor ing to Manning and Chamberlain, und the most parsimonious assumption th left-side cradling behavior is homologo in humans and apes, that preference ma have originated at least as early as th common ancestor of humans and Africa apes, some six to eight million years ago

The questions remain: Why do some f male primates show such a strong te dency to carry babies on their left side And why don't males show the same te dency? Salk's 1973 hypothesis was th placing a newborn infant on the left sid brings the baby closer to the sound of th mother's heart, which has a soothing e fect on the infant. For biological reason including suckling, the mother is mo likely than the father to hold the baby du ing the very early stages of life outside th womb. And evidence presented by Sa suggests that even among mothers, th length of postpartum separation is critic in establishing the preference for left-sid cradling. Mothers who experienced n postpartum separation showed the lef side preference, whereas mothers who ex perienced prolonged separation (twenty four hours or more) showed no distinc lateral preference, although somewha more of them preferred to hold their babie on the right side.

An alternative hypothesis (Mannin and Chamberlain) is that left-side cradlin confers a twofold advantage based on pa terns of lateralization (or handedness First, the mother is better able to monito her baby's well-being with her left eye an left ear (and this information is the processed in the mother's right cerebra hemisphere, where most emotional pro cessing takes place); and second, the bab is better able to monitor his or he mother's emotional condition because th left side of her face (the more expressiv side, being controlled largely by the righ cerebral hemisphere) is nearest the baby.

What about the relationship, suggeste by Connie Spiegel and other letter writers between doing certain types of work an baby-carrying preference? Interestingly Salk noted that, when asked why they ca

d their babies on the left side, left-
ıded mothers replied that they could
d their babies better that way. Right-
ıded mothers replied that holding a
by on the left side freed the right hand to
other things.

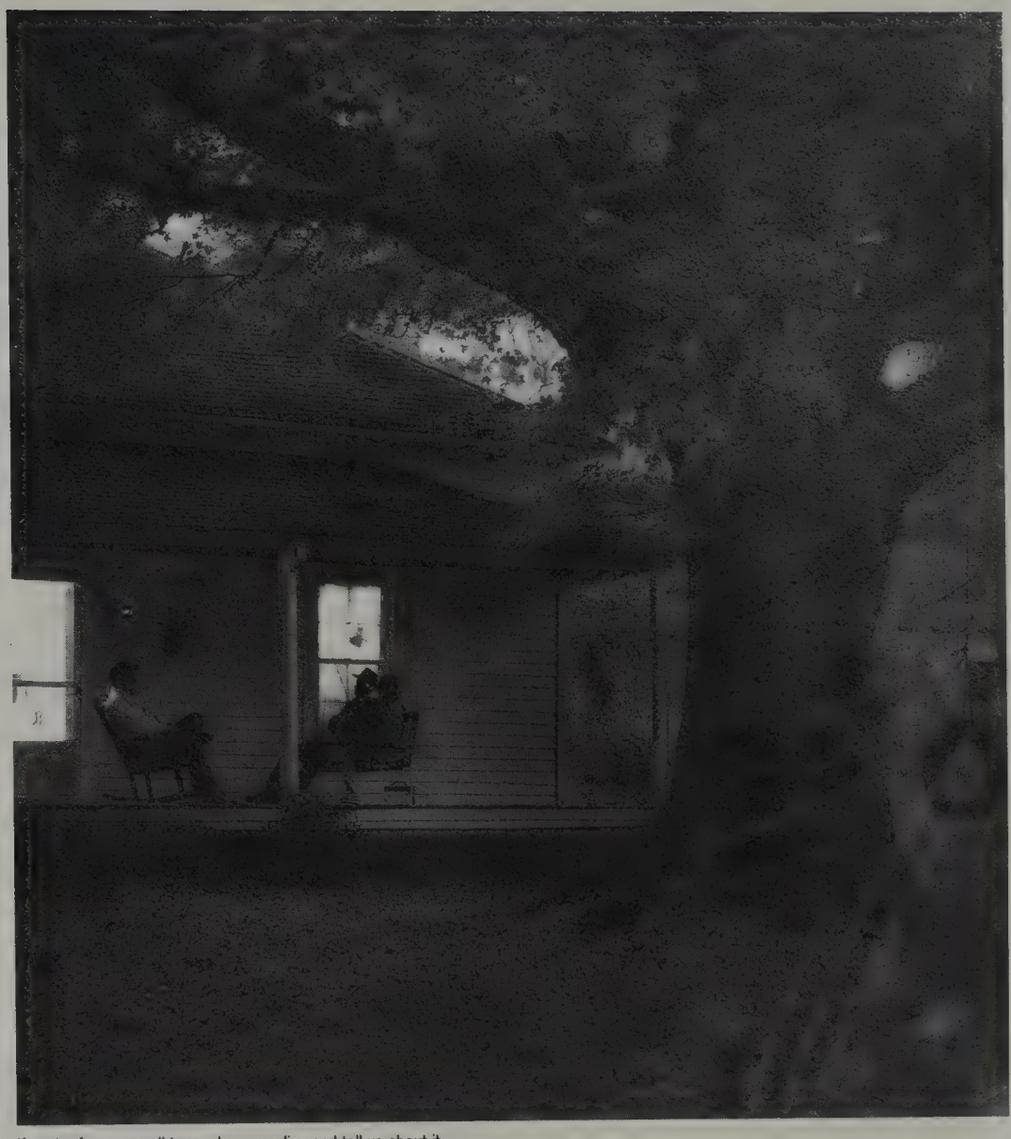
THE SCENT OF ICE CREAM

Raymond Sokolov's ideas on the rela-
ıship between ice cream's temperature
d flavor were enjoyable ("A Matter of
ste," August 1993); however, my expe-
ıce with police detector and tracking
gs made me wonder if concentrating on
cream's texture has not thrown him
ff the scent."

Ice cream at 15 to 30 degrees goes into
body-temperature mouth. The tempera-
e differential triggers rapid convection
through the oronasal cavity. Volatile
s and alcohols in the flavoring vaporize
ickly over a numbed tongue and "chim-
y" up to scent cells. This could mean ice
eams have an ideal serving temperature
which the strength of the intended flavor
at its highest before other odors drown
t or negate the ability to identify it. Too-
ld ice cream may be swallowed before
e flavoring fully vaporizes. Truly melted
e cream may have already lost much of
detectable flavor odor, leaving only its
ıer contents' scents, before it reaches the
outh.

This explanation resolves two excep-
ons to the texture theory: milkshakes and
eeze-dried ice cream. Milkshakes, my
vorite, retain the temperature and food
ıvor of ice cream although their texture
"degraded" by stirring and the addition
milk. Freeze-dried ice cream, originally
veloped for NASA flight menus, is sold
backpackers as a small square resem-
ing dried, beaten egg whites. Eaten unre-
onstituted, a bite is rehydrated by saliva
a consistency resembling Sokolov's fa-
orite ice cream. Yet its flavors are never
rich as chilled ice cream. The small
mperature differential and lack of mois-
re would limit odor's circulation to the
asal tissues.

JIM GREENWAY
Fairmont, Georgia



If you're from a small town, drop us a line and tell us about it.

IN THE SMALL TOWN of Lynchburg, Tennessee, nothing seems to change but the seasons.

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Ants That Pay the Piper

A small tropical tree derives subtle benefits from its insect tenants

by Deborah K. Letourneau

The lush, verdant rain forests of Costa Rica are alive with the rustling of spider monkeys leaping from tree to tree, the roaring of howler monkeys, and the calls of tropical birds—raucous macaws, low-pitched motmots, and forest-piercing toucans. Much more quietly, tens of thousands of other organisms are making a living and carrying out their singular functions within the forest community. Enthusiastic visitors to this realm might well peer up at the life in the canopy with their binoculars and walk on without noticing the intricate and subtle interactions—predation, parasitism, and partnership—going on in the understory foliage. One rich center of such interactions is a small tree in the genus *Piper,* one of the tropical ant plants.

First described by European naturalists in the 1800s, ant plants encourage ants to reside inside them by providing the insects with food and shelter. Ant plants are diverse; they include pudgy, tuberous plants that cling to the branches of forest trees Borneo, fast-growing umbrella trees tropical America, thorny acacias of t African savanna, and the stately chief tr of the Solomon Islands, so named becau no other tree crown touches it. In ea case, benefits accrue to both ants a plants when they live together. Such pa nerships, or mutualisms, are coming und more intense investigation as scientists a tempt to understand the "glue" that hol complex biological communities togethe

The *Piper* ant plants that I have studie since 1978 are treelets in the black pepp family that grow in the shade of the trop cal forest of Central America. The fo species in Costa Rica, where I have do most of my work, range in height fro three to fifty feet when they become m ture enough to produce flowers. Th leaves are as large as a human hand and r main on the tree for more than a yea Two- to five-inch flower stalks are erect dangling, depending on the *Piper* specie and when the seeds ripen, they a grabbed by bats on the wing. After th seeds pass through the bats, they are e creted and sprout as new treelets at som distance from the parent tree.

Piper plants provide both food an shelter for a single species of ant, *Pheidol bicornis*. Reddish brown and tiny (thirt could fit on a penny), these ants can b seen trundling up the stem and along th leaves of some *Piper* plants. By the tim young *Piper* trees have just two or thre full-sized leaves, one of the leaf bases— hollow swellings between the branch an the leaf itself—usually contains a *Phei dole* queen. She colonizes a *Piper* saplin by chewing an entrance hole and layin eggs inside the leaf base. When her egg first hatch into larvae, she and the youn occupy one of the leaf bases, but as th colony grows, the worker ants graduall



To rid their host plant of potential herbivores, Pheidole *ants typically remove eggs laid by other insects on* Piper *leaves. Here, three workers carry off a fragment of a termite carcass that has been placed on a leaf by researchers.*
Sandy Upson


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Winged reproductive adults, major and minor workers, and ant brood can be seen in this cross section of a leaf base. The small spheres are food bodies produced by the plant and eaten by the ants.
Stephen J. Krasemann; DRK Photo

hollow out the stem pith tissue, and the entire plant becomes a domicile.

This lodge is also a source of food; the inside surface of the expanded leaf bases produces single-celled, opalescent food bodies that look like dust lining the chamber walls. Ants pluck these oil- and protein-rich morsels from the walls and feed them to the fat, pale larvae, which eventually metamorphose from wormlike creatures into industrious worker or reproductive ants.

Pheidole ants have never been seen foraging anywhere but on their home *Piper* plants, so the plant-produced fatty food bodies are probably the ants' main source of sustenance. The late ecologist Stephen Risch and phytochemist Fred Rickson found that, unlike other ant plants, which produce ant food even after the ant colonies are removed, *Piper* ant plants manufacture food bodies only when *Pheidole* ants are in residence. Perhaps the *Piper* evolved the capacity to halt food production in the absence of *Pheidole* either to conserve energy or to favor their particular "partner" ant species.

Just why should *Piper* or any ant plant go to pains to attract and keep a colony of ants? We know that in many cases, ants "pay their rent" by providing their host with nutrients. Risch and his colleagues proposed that decaying ant excrement and body parts, deposited inside the plant stem, are absorbed in the form of aqueous ammonia through the plant's soft inner tissues. In addition, the respiring colony members may enhance the health of the plant by increasing the concentration of carbon dioxide within it.

Getting food from an animal source is especially important to ant plants growing in poor soils or other nutrient-poor conditions. *Hydnophytum,* an epiphyte living on the branches of rain forest trees in Borneo, is a classic example. Biologist Camilla Huxley, of Oxford University, has shown that these plants have special absorptive surfaces that take up nutrients deposited in ant excrement. Since the ants on *Hydnophytum* also forage elsewhere, on richer grounds, their excrement is an excellent fertilizer. But unlike *Hydnophytum, Piper* plants grow in relatively rich habitats, and their ants don't stray.

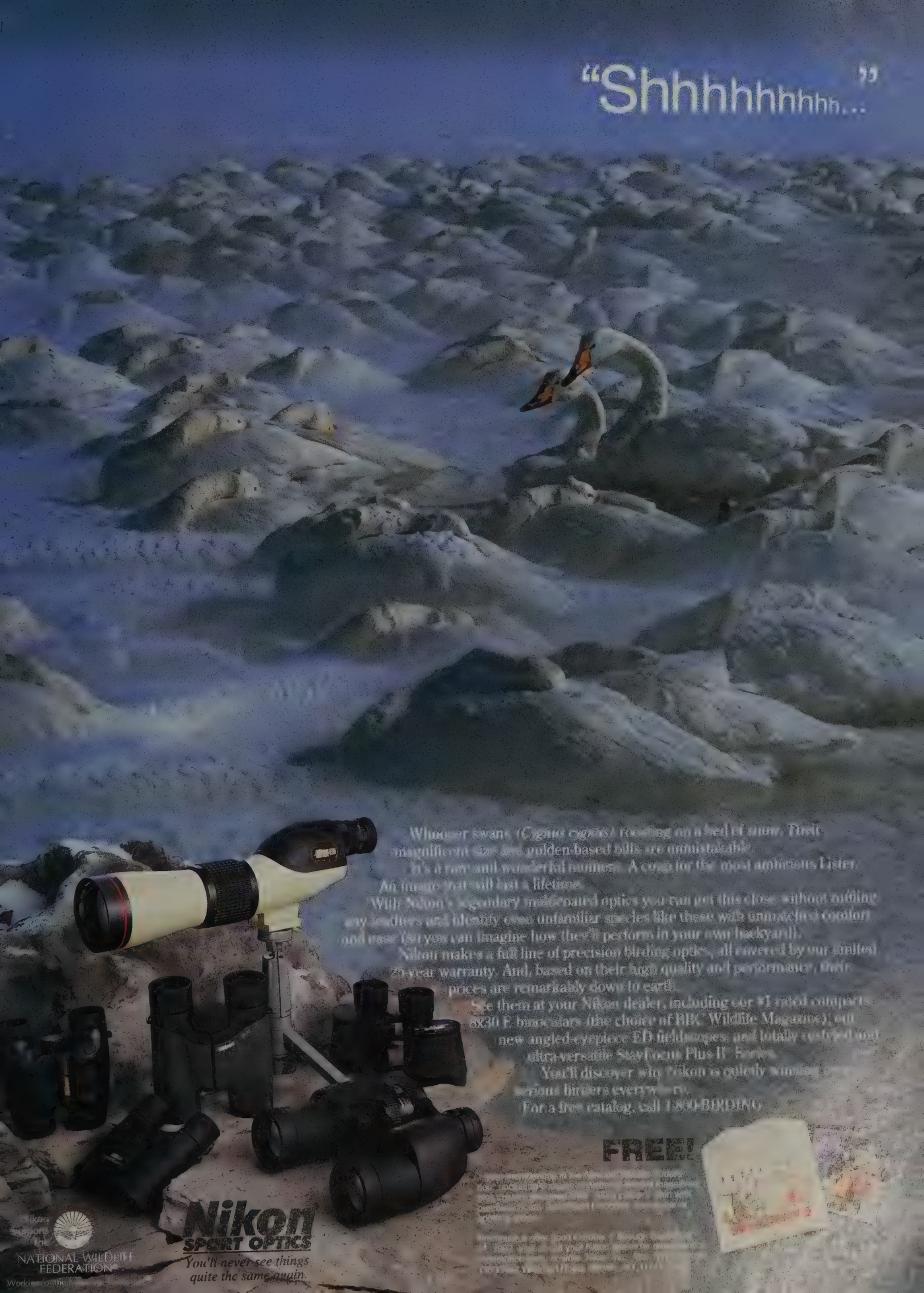
To find out whether *Piper* ants contribute nutrients to their plants in some other manner, my co-worker Feynner Arias removed the contents of some of the ants' digestive tracts, using tiny dissecting tools fashioned out of insect pins. I compared the material scooped from the ants with the microscopic excrement deposited within the plant stem and with tiny organic particles on the plant leaves. They hav common elements. Foraging *Pheidol* ants, then, appear to take up a variety o particles, such as minute spores, frag ments of algae, and moth scales, and carr them into the plant in their crop—a sto age sac that holds the collected food unt it is regurgitated and fed to the larvae Eventually, these nutrients may fertiliz and thus benefit, the ant plant.

Another valued service rendered to ar plants by their ants is defense against her bivores. Resident ants may ward off othe animals—from insects to mammals—b menacing displays, aggregating, bitin and stinging. A pastime of intrepid fiel biologists in Costa Rica is to maneuve newcomers to tropical research into clos contact with the famous ant acacia, full o *Pseudomyrmex* ants, whose powerfu stings startle even the hardiest and mos enthusiastic of inexperienced biologists.

Unlike these warriors, *Pheidole* ants ar docile. Because they move slowly and d not attack or sting, some researchers be lieved that *Pheidole* did not provide an active defense of their plants. I wanted t take another look at the behavior of thes ants; I suspected that they may have bee undermining herbivores in a less dramatic but still effective, way. Many leaf eaters— such as caterpillars and beetle larvae—ar rive on plants as eggs. I reasoned that ant might be dispatching potential herbivore at this vulnerable stage. To find out, I con ducted some experiments in Corcovad National Park in southern Costa Rica. placed termite eggs on new leaves o *Piper* plants. In most cases, a *Pheidol* worker ant discovered the egg within a hour of its placement, picked it up in it mandibles, and walked away with it. Al though many eggs were taken into th plant and presumably fed to the larvae more than half the time, the ant walked t the edge of the leaf and simply droppe the egg to the forest floor.

Slow-moving *Pheidole,* then, was in it own way disrupting some potential herbi vores. But this subtle form of defense i not 100 percent effective. In a rain fores reserve that is part of a private farm nea the Panama border, field assistants Roma and Leonel Gomez monitored herbivor damage on *Piper* plants with and withou ants for several years. Twenty-five plant were kept ant-free by introducing an ex tremely dilute droplet of insecticide di rectly into the sheathing leaf bases wher ants harvest the food bodies.

Ant-occupied plants had a mean leve of 12 to 15 percent of leaf area removed by


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herbivores, while plants without ants suffered typical leaf damage of 35 to 40 percent. The main culprits were inchworms, moth larvae that feed on the underside of ant-free leaves, where they make a characteristic scraping pattern. While total levels of herbivory were reduced by the ants' low-key defense, some insects, such as katydids and adult beetles, were less susceptible to it, and these accounted for most of the 12 to 15 percent of leaf material eaten on ant-inhabited leaves.

Does leaf damage reduce the *Piper* plant's ability to grow and reproduce? Curiously, all my efforts to harm plants by removing leaves (up to 50 percent of each leaf on all test trees for five years) have failed. We now have strong evidence that we have been looking at the problem in a traditional, but misleading, way. In terms of herbivore damage, a view from inside-out may hold the answer to how these little ants truly benefit the plant. Whereas plants with ant colonies that have repeatedly had parts of leaves removed still grow and produce seeds, plants from which ants have been excluded produce very few flowers. This decline is not due to leaf-feeding insects; it is caused by an invader. The weevil *Ambates melanops* attacks a large proportion of unoccupied plants and kills the stem by boring it from within. These weevils rarely manage to kill a stem when plants have ant custodians. The ants attack the vulnerable, soft-bodied weevil larvae as they tunnel into the inner stem to feed. Plants without ants are marked by multiple, large tunnels from weevil larvae, while plants with ant colonies reveal tiny tunnels abruptly ending at ant-inhabited points.

On another level of predation, however, the ant custodians themselves have enemies from which the plant can offer little protection. *Pheidole* ants are subject to attack when they leave the security of the leaf stems for the outside of the plant. Specialized spiders in the genus *Dipoena* spin and position themselves within webs at exit holes used by ants leaving the interior of the plant. As an ant emerges, the spider captures it in the web and injects it with an immobilizing toxin. Rendered helpless, the ant is devoured. I have also discovered that both ants and the plant are sometimes undermined even within the leaf base strongholds.

When I looked within the plant for intruders, I found that predators of another variety, beetles in the genus *Phyllobaenus,* lay eggs along the edge of the plant's leaf bases. When the larvae hatch, they enter the plant, settle into a small cylindrical space, and spin a barrier that isolates them from the plant's resident ants. Here they grow and develop. When they have grown to about ten times the size of worker ants, they remove the barrier and station themselves so that their soft bodies are protected in the cylinder of the leaf base, while their formidable jaws meet any oncoming worker ants. As the ants attempt to attack a larva, the larva turns the tables. Using its mandibles, it captures the ants, crushes their heads, and tosses the disabled or dead workers aside. When the coast is clear of defending ants, the larva begins to feast on the ant brood.



Having killed the plant's resident ants and thrown them in a pile, an invading Phyllobaenus *beetle larva has "tricked" the plant into continuing to produce food bodies.*
D. H. Feener

What do the beetle larvae feed on in the early stages while still isolated from their prey? We were able to answer this question after we happened upon an unusual population of *Piper* ant plants in Costa Rica's Carara Biological Reserve, where more than 90 percent of the plants lack ants. Just as we expected, most of the petiole chambers on these antless trees were smooth and lacked food bodies. Yet we were surprised to find that others contained hundreds of food bodies. In every case, the chambers with food also contained a *Phyllobaenus* beetle larva. We were seeing food bodies where there were no ants and predators where they were no prey. Were these specialized predators able to trick the plant into feeding them We transferred seven beetle larvae t clean, smooth petioles on trees lackin ants, waited eighteen days, and the checked the chambers again. Each newl inhabited chamber was loaded with foo bodies, just as it would have been if ant were occupying the plant. The beetle have broken the code by which *Pheidol* ants stimulate the plants to produce fooc By exploiting the peaceful partnership o ants and plant, the beetles qualify as para sites on the mutualism. As yet, no on knows exactly how the beetles accomplis this feat, but we speculate that both th ants and the beetles lay down chemical that induce the plant to feed them.

The longer I investigate *Piper* plant and their contingent of insects, the mor complex and intriguing the web of rela tionships appears. In the confines of small tree, silent dramas—complete wit life and death struggles, predation, an partnership—play themselves out. The plants, ants, eggs, opportunistic weevils predacious spiders, and trickster beetle are a microcosm of the diverse and multi layered life of the rain forest.

Deborah K. Letourneau is an associat professor of ecology in the Department o Environmental Studies at the University o California at Santa Cruz.



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The Razumovsky Duet

While one wealthy brother supported Beethoven, the other turned a deaf ear to a pioneer of natural history

by Stephen Jay Gould

I live on a small street of some twenty houses, all packed together. I presume that most of my neighbors share my mental geography of this terrain—structural divisions into roadway, sidewalks, houses, and gardens, with primary taxonomic separations set by property lines of ownership. But the street also features more cats than people—and I know that these members of the mammalian majority divide the space differently. They clearly have some sense of ownership and territory—for charges, howlings, and spats occur daily—but their parsings do not match the human separations. Think what we might understand about mammalian mentality if we could ever obtain the cat map of Crescent Street. A potential informant does share my living quarters, but he has been persistently unresponsive and uncooperative (and he still gets fed!).

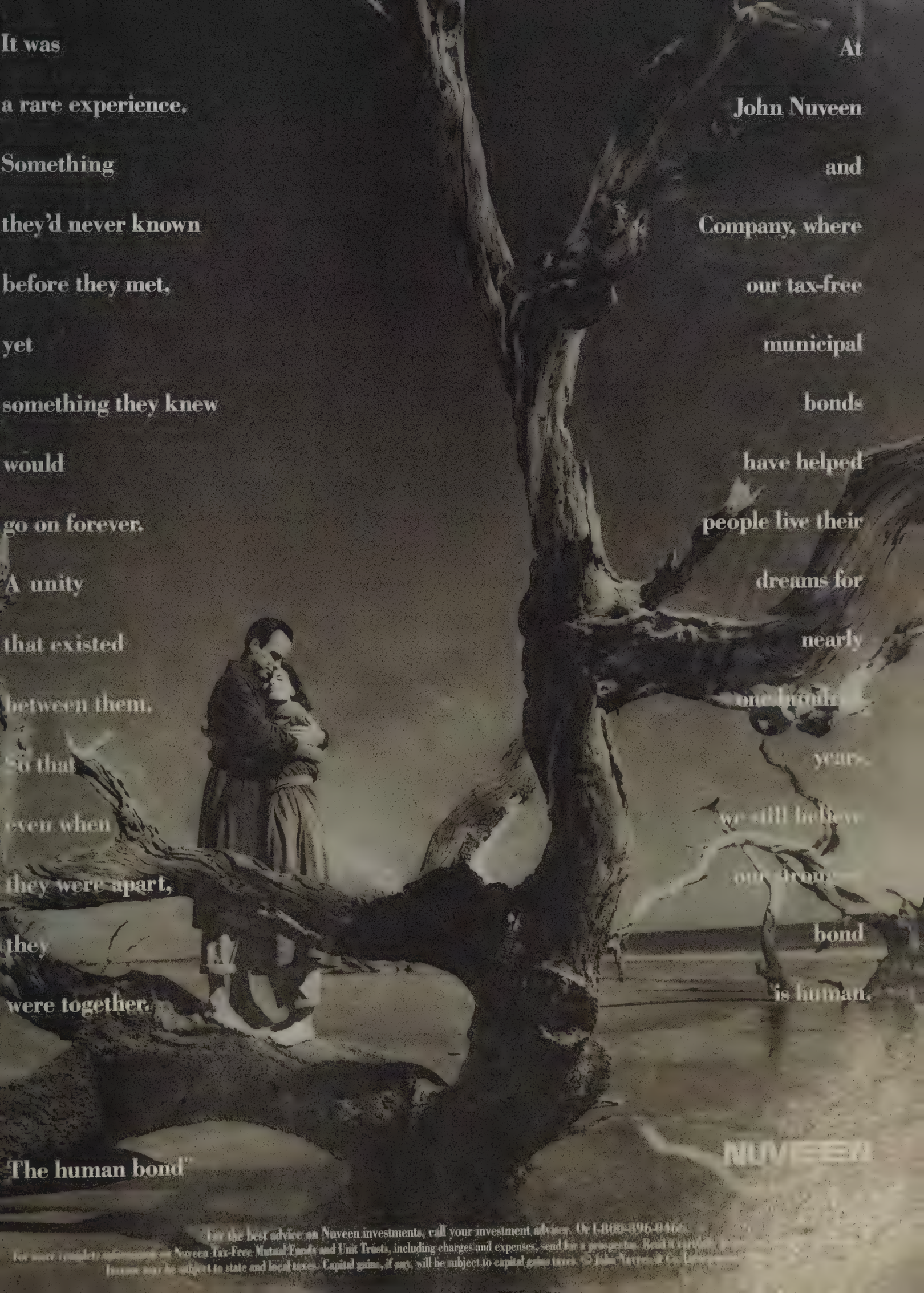
In a zoologically more restricted framework, this important theme of alternate mappings might give us great insight into differences among human cultures, times, and mentalities—as the French *annales* school of historians has taught us, with its emphasis on changing patterns in ordinary life, featuring working men and women, rather than kings and conquerors (for an excellent example, see the multivolumed *History of Private Life,* edited by Philippe Ariès and Georges Duby, and published by the Harvard University Press). In school, I learned the conventional history of dates, nations, and battles. My mental maps of time and geography all follow the usual lines: temporal divisions by kings and presidents; spatial boundaries by nations and languages. But other systems also make sense and have more relevance to people whose primary activities enjoin different divisions.

I assume that sailors prefer size or function over place of registration as a criterion for classifying vessels (especially when so many ships, for reasons of taxation and licensing, officially carry the Liberian or Panamanian flag). My *Cerion* snails do not recognize a political separation between the Bahamas and the Turks and Caicos Islands, for these places form a unified climatic and geographic province well suited to molluscan life styles (yet I have long been frustrated by the difficulty of obtaining maps with both political entities shown in the same way and to the same scale). This essay emphasizes the artificiality of conventional linguistic and national boundaries in European history—by telling a story about scientists and artists who might have parsed the early nineteenth century world along different lines of patronage.

So many projects, both little essays like this and lifetimes of effort, begin by accident: you can't, after all, explicitly search for the unexpected. I bought an old book a few months ago, largely because it was so underpriced and the opportunity would therefore not arise again. Its author—Johann Gotthelf Fischer von Waldheim (1771–1853)—cannot claim a place in the conventional pantheon of great scientists. But he occupies a small spot in the heart of paleontologists as one member of the pioneering generation who established the basic ordering of life's history when scientists codified the geological time scale. We also owe a debt of thanks to Gotthelf Fischer (to cite the abbreviated moniker that he used in most of his own publications) for popularizing, and perhaps inventing, our modern name of paleontology. (Otherwise, we might still be stuck with one of the earlier, unpronounceable alternatives, like oryctology.)

Fischer was German by birth (from the town of Waldheim in Saxony, whic Fischer added to his name when the Rus sian czar ennobled him in 1817). He stud ied with Cuvier, became friendly wit Goethe, traveled with the Humboldt broth ers, taught in various German universitie and finally, in 1804, moved permanentl to Russia as professor of natural histor and director of the natural history museur at the University of Moscow. Lest his la post seem anomalous, Fischer's emigra tion followed a common pattern fostere in Russia ever since Peter the Grea (1672–1725) sought to leap over Russia scientific backwardness by importing spe cialists from other nations and by purchas ing foreign collections. (Peter develope his own great museum of natural his tory—still partly on view in the buildin constructed to house it, the Kunstkamer in Saint Petersburg—by acquiring two im portant Dutch collections.)

The growth of Russian universities du ing the late eighteenth and early nine teenth centuries provided another pathwa for importation of foreign scientists an professors—for Russia, lacking univers ties in its past, could not subsist on home grown specialists. Fischer's residency i Moscow, beginning in 1804, lies sand wiched between arrivals of the two grea est German-speaking biological émigré to Russian universities—Peter Simon Pa las in 1768 (see my column of May 199 and Karl Ernst von Baer in 1834. (Bot men taught in Saint Petersburg. Pallas wa born in Berlin, while von Baer belonged t an old Prussian family, then living in Esto nia. Von Baer, the greatest embryologist o the nineteenth century, was imperial Rus sia's greatest academic "catch." He dis covered the human ovum in 1827 bu abandoned embryological research for a astonishing variety of brilliant studies i



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ethnology, anthropology, and geomorphology during his Russian years.)

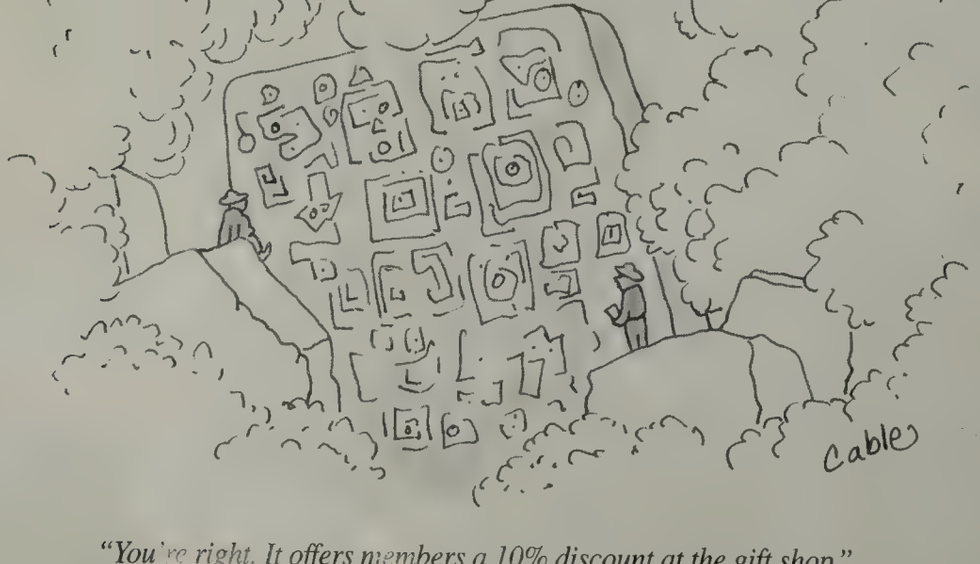
Fischer had a remarkably fruitful and successful career in Russia. He founded three journals (published in French), and wrote nearly 200 books and articles (also predominantly in French) during his Russian years. His wide-ranging articles spanned all of zoology but concentrated on pioneering work in describing living Russian insects and fossils of all groups. Fischer was widely recognized by the international scientific community and became an active or honorary member of nearly ninety institutions and academies, including the American Association of Arts and Sciences in Boston and the American Philosophical Society in Philadelphia. At Fischer's jubilee in 1847 (to celebrate the fiftieth anniversary of his doctorate), Alexander von Humboldt (the world's most popular living scientist at the time) extolled him as *mein edler, ältester Freund,* "my noble and oldest friend." Fischer wrote home to his friends in Waldheim, describing the ceremony. He spoke of the six carriages that led the way, five drawn by four horses and the last one by six. He described the gifts and the encomiums, ending with his reaction: *Hier brachen mir die Thränen der Dankbarkeit aus meinen Augen,* "this brought tears of thanks to my eyes."

The book that I bought is not one of Fischer's paleontological works but a superb example, published in 1813, of a genre that computer technology has driven to extinction—bibliographic compendiums of alternative systems for classifying objects, in this case all genera of the animal kingdom. Fischer uses Linnaeus's account of animal genera as a framework, but in a series of ingenious tables, charts, and lists, he displays the correspondences between Linnaeus and all other major systems proposed by leading zoologists, mostly French and German. (The visually attractive result looks like a chart of comparisons among the three synoptic gospels or among various biblical translations.) The effort may be primarily bibliographic, but we learn much of historical and theoretical interest from Fischer's compilation. For example, historians have often claimed that Lamarck's *Philosophie zoologique,* his major exposition of evolution written in 1809, was widely ignored as a fatuous and speculative treatise. But one of Fischer's longer charts presents a *Tabula clarissimi Lamarck* (list of the most celebrated Lamarck), reproducing Lamarck's chain of being in full evolutionary order just four years after its publication.

The title of Fischer's book records its intended audience and utility: *Zoognosia: tabulis synopticis illustrata, in usum praelectionum Academiae Imperialis Medico-Chirurgicae Mosquensis* (Zoological knowledge: illustrated with synoptic tables for lectures at the Royal Academy of Medicine and Surgery in Moscow). Such single-volume compendiums must hav been especially useful for students with s little access to extensive libraries and col lections. (My own copy went to an eve more peripheral location with even mor limited primary material, for Fischer ha inscribed it "to the Society of Arts and Sci ences of Courland"—a duchy on th Baltic Sea, now part of Latvia, that be came a Polish fiefdom in the sixteenth cen tury, but passed to the Russian empire i 1795 after the third partition of Polanc Courland enjoyed a seventeenth-centur moment of glory and even held enoug power to build a small colonial empire i the West Indies [Tobago] and Afric [Gabon].)

I love to read the dedications of ol books written in monarchies—for they in variably honor some (usually insignifi cant) knight or duke with fulsome word of sycophantic insincerity, praising him a the light of the universe (in hopes, n doubt, of a few ducats to support futur work); it all makes me feel like such a honest and upright man, in comparison when I put a positive spin, perhaps ever s slightly exaggerated, on a grant proposa Fischer's dedication to *Comes Illustris sime, Domine Clementissime!* (Most illus trious count and most compassionat lord!) first stuck me as an example of *vi ordinaire* within the genre. But two fea tures of the text sparked my interest. Firs Fischer's lament over impediments to hi research seemed more fervent and mor extreme than usual—for evident reason most easily inferred. He writes that he i dedicating his book to the illustrious coun and would also like to so dedicate the nat ural history collections of the museum, bu *eheu, omnes perierunt, restant paucissi mae* (Alas, everything has been destroyed so very little remains). He then asks wha will happen *post tot calamitates luctuosa casusque tristissimos, quos Musarum cul tores Mosquensis experti sumus* (after s many sorrowful calamities, and so man most dismal events, that we supporters o the muses of Moscow have endured).

I happen to be writing this essay on Jul 4, so local events in Boston are primed t dramatize the source of Fischer's com plaint. Just before sunset, as they do ever year, the Boston Pops Orchestra, on the es planade adjoining the Charles River, wil play Tchaikovsky's *1812 Overture,* wit glorious fireworks commencing at th booming of cannons (marking the conclu sion of this loudest piece in the classica repertory). When I was a child, wallowin in patriotism, I couldn't quite figure ou



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why Tchaikovsky had written an overture to celebrate an American war. I discovered later that other events occurred in 1812, notably, as celebrated by Tchaikovsky, the capture of Moscow by Napoleon, followed by his decisive defeat, as the old saying goes, by those greatest of Russian generals, November and December.

Napoleon had entered Moscow on September 14, hoping to win quick and favorable peace terms from Czar Alexander. But the czar would not deal with him and, more importantly, a massive fire had broken out in Moscow on the day of Napoleon's entry, eventually destroying more than two thirds of the city and preventing Napoleon from feeding and housing his troops through the winter. The fire may have aided Russia by helping to force Napoleon's withdrawal and subsequent defeat, but the flames also wrecked most of Moscow, including the great libraries and museum collections of the university. Fischer, in other words, had been one of so many victims, largely anonymous to later history, of a signal event in the construction of our modern world.

I then considered a second intriguing feature of Fischer's dedication, the identity of the illustrious count from whom he sought patronage (and not so subtly) by ending his dedication: *in Te, Comes Illustrissime, spes omnis nostra collocata est* (All our hope is placed in you, most illustrious count). Fischer dedicated his book to Alexis Kirillovich Razumovsky, the Russian minister of public instruction.

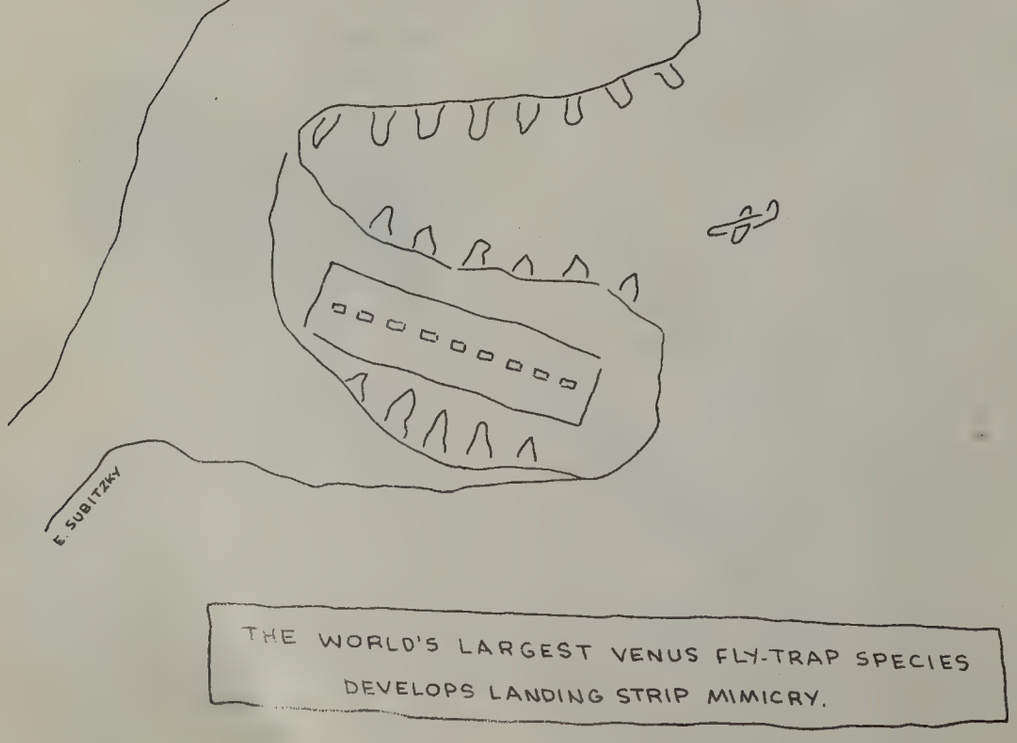
Now, speaking of music, and going back a generation or two from Tchaikovsky, here is a Russian reference known to all lovers of the classics—for Beethoven dedicated three of his most famous string quartets (Opus 59) to a gentleman of the same name. (They are, in fact, called the Razumovsky Quartets, and the first two feature Russian folk melodies in their composition.) I couldn't help wondering about the relationship between Beethoven's actual and Fischer's anticipated patron. Beethoven wrote the quartets in 1806, and Fischer sought help seven years later, so the events are nearly contemporaneous. The story, as so often happens in our continually fascinating world, turns out to be well worth reporting.

Beethoven's patron, Andrei Kirillovich Razumovsky, was the brother of Fischer's *Comes Illustrissime*—but the resemblance extends little beyond genealogy. Their story begins two generations back with a Ukrainian Cossack named Grigor Rozum, who had two remarkable sons. Again, music was the prod to success. One of his sons, Aleksei Grigorevich Razumovsky (1709–71), became a singer in the court choir of Saint Petersburg. There he attracted the attention, and later the love, of Princess Elizabeth, who became czarina of Russia in 1741. Aleksei secretly married Elizabeth in 1742. They had no children, and Aleksei took little interest in affairs of state. But he remained the favorite of his secret wife and became enormously wealthy thanks to her largess. His brother Kirill Grigorevich (1718–1803, father of the Razumovskys in our tale of Fischer and Beethoven—as their common patronymic, Kirillovich, indicates), was a more ambitious and accomplished man. He served for nearly twenty years as president of the Saint Petersburg Academy of Sciences, but held much greater political power (including dominion over more than 100,000 serfs) as the last hetman of Little Russia (ruler of the Ukraine). His two sons therefore inherited all conceivable advantages of wealth and position.

The younger son—Andrei Kirillovich Beethoven's Razumovsky (1752–1836)—was a warm, generous, and liberal man and one of the great art patrons of Europe. He spent his professional life as a diplomat in central Europe, wooing women (most notoriously, the Queen of Naples) and making deals. He served as Russian ambassador to Vienna from 1790 to 1799 and again from 1801 to 1807. Razumovsky remained in Austria for the rest of his life, serving as a leader of the Russian delegation at the Congress of Vienna in 1815 (where Napoleon's spoils were split among the victors, thereby establishing yet another connection to Fischer and the opposite side of our story). For his service Andrei Razumovsky was promoted from count to prince by the czar.

Music had always been Razumovsky's first love (maybe his second, following women). In his initial post as clerk for the Russian embassy in Vienna, he certainly knew Mozart and probably met Haydn. He was a more than merely competent violinist and often played in the quartet that he established, largely for Beethoven's use. But he performed his finest service for music as a patron. Paul Nettl's *Beethoven Encyclopedia* (New York: Philosophical Library) states: "Razumovsky was the most generous Maecenas of his time, supporting artists, musicians, and painters. His picture gallery and musical parties were famous throughout Europe. A well-educated, liberal, and generous aristocrat and brilliant *causeur,* he was one of the most popular and renowned aristocrats of the late 18th and early 19th centuries."

Razumovsky certainly knew and supported Beethoven as early as 1796, for his name appears on the subscription list to Beethoven's trios, Opus 1. When the Razumovsky Quartets were written nineteen years later, the Russian nobleman took title to controversial music, not to pretty oom-pahs—so we must respect his



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support for artistic license. Many musicians could not grasp or stomach the score's unconventionalities. When one Italian player belligerently asked if Beethoven truly regarded the quartets as music, the master replied: "They aren't for you, but for a later age." Beethoven also dedicated his fifth and sixth symphonies jointly to Razumovsky and to Prince Lobkowitz.

As his finest testimony and favor to Beethoven in 1808, Razumovsky established and funded a permanent string quartet, led by Schuppanzigh—and placed the players at Beethoven's disposal. A contemporary observer noted: "Beethoven was…cock of the walk in the princely establishment; everything that he composed was rehearsed hot from the griddle and performed to the nicety of a hair, according to his ideas, just as he wanted it and not otherwise, with affectionate interest, obedience and devotion, such as could spring only from such ardent admirers of his lofty genius."

This happy situation persisted until 1816, when Razumovsky held a gigantic New Year's Eve party to celebrate his elevation to princehood after the Council of Vienna. He could not accommodate the 700 guests in his capacious palace, so he built an adjacent wooden structure for supplementary space. This addition caught fire, which spread to the main palace, consuming the great library and all the works of art and destroying the prince's most famous space—a room full of Canova's statues, reduced to dust and fragments as the ceiling collapsed. Razumovsky, devastated in both spirit and pocketbook, disbanded and pensioned off his quartet.

The older son—Aleksei Kirillovich, Fischer's Razumovsky (1748–1822)—lacked nearly all of his brother's admirable characteristics. Standard sources (not only the Soviet *Encyclopedia,* which might be accused of bias, but others likely to be both more objective and sympathetic) describe him as indolent, dyspeptic, litigious, domineering, and generally miserable. He married the richest heiress in Russia but sent her packing several years later after draining most of her wealth. Of his two sons, one was wildly dissolute and the other floridly mad (his two daughters sound quite admirable—one devoted herself to establishing hospitals for the poor—but sexist sources and limitations provide little information about their lives and fates).

Razumovsky hated court life and largely sought to avoid public responsibilities. But he did love botany and natural history, and he established, at his estate in Gorenski near Moscow, a wonderful botanical garden (specializing in alpine plants) and the most extensive collection of books on natural history in Russia (including the library of P. S. Pallas, which he had purchased). Nonetheless, Razumovsky rarely used these resources to benefit either science or the public. A contemporary observer commented (probably not impartially): "Count Aleksei Kirillovich has enclosed himself in his property at Gorenski in order to vegetate there with his plants. He is doing with his knowledge the same thing that he does with his immense fortune—that is, it all stays with him and confers no profit upon others."

Razumovsky did, generally after much persuasion, accept some governmental responsibilities, most notably as minister of public instruction, beginning in 1810 (where sources describe him as largely inactive, but by no means incompetent). In this post, he advocated some reforms, notably the suppression of corporal punishment in the schools. He did not, however, act as an advocate of the field he supposedly loved, for he argued that study of natural history need have no place in the training of statesmen and politicians. He adopted a similar hands-off policy in dealing with Russia's universities. In his 1988 book, *The University Reform of Tsar Alexander I,* James T. Flynn writes: "Razumovsky gave so little active leadership that each university was left to its own devices to work out its foundation and development. This circumstance magnified the importance of each local curator, as well as the particular local situation, and minimized the importance of the statutes and the ministry." Not necessarily a bad thing.

Razumovsky is best known as the confidant and supporter of the deeply conservative social thinker, Joseph de Maistre, perhaps best remembered for his quip that the public executioner is the guardian of social order. Maistre left France during the revolution for a life in Switzerland. He spent many years in Saint Petersburg as diplomatic envoy from the king of Sardinia. There he met Razumovsky, directed his letters on public instruction to the Russian minister, and convinced him to support a variety of conservative doctrines—including increased press censorship and greater integration of religious instruction into the curriculum.

In short, Aleksei K. Razumovsky seems an awfully poor choice as Fischer's hope for active support in rebuilding Moscow's natural history library and collections. Too bad his brother was off playing second fiddle (literally) in a Vienna quartet. Still, I suppose one has to begin with the minister of public instruction in such a dire situation and hope for the best.



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The full extent of Fischer's plight may be appreciated from an extraordinary letter that he wrote on November 20, 1812, to his German-speaking colleague Nikolaus Fuss, secretary of the Royal Academy of Science in Saint Petersburg (quoted in the only available biography by J. W. E. Büttner—*Leben und Wirken des Naturforschers Johann Gotthelf Fischer von Waldheim,* Berlin: Akademie Verlag, 1956): "All scientific institutions are destroyed. Our university has lost so much. Of our library and museum, I was able to save so little—only the best things that I could quickly pack into 20 boxes. What is this against the beautiful totality! [*Was ist das gegen das schöne Ganze!*] Your Fischer has lost everything."

Fischer then details the destruction. Of 5,000 books in his library, he saved only five (which happened to be in his carriage at the time). He lost his most precious items, including a completed manuscript on fossils and his personal copy of Linnaeus's *Systema naturae* with twenty years worth of annotations. Nearly all the natural history collections were destroyed, and Fischer particularly lamented his beautiful collection of skulls, his insects, and his dried plants. He also lost all his "anatomical instruments," his "mineralogical apparatus," and even 130 copper plates for engravings, "including the large plate of the mammoth skeleton."

But as he writes to Fuss, a strange alchemy takes hold, and Fischer's zeal and optimism break through: "We seek to console ourselves with the thought that we are healthy, and that we do not lack bread. I do not know if I will be able to finish my *Zoognosia,* as only nine sheets have been printed [I am delighted that my volume—the completed *Zoognosia*—illustrated the happy negation of this fear.] I am now working on the latest edition of the *Onomasticon Oryctognosiae* [list of names of rocks and fossils]. The work lets me forget all my misfortunes and makes me most happy."

What more honest and telling mark of a true scholar—to seek solace in intellectual work and to rebuild by painstaking skill, all that misfortune had destroyed. To an old friend, the rector of his school in Waldheim, Fischer wrote: "To be sure, I have lost everything. But I judge myself as so much more lucky than many of my fellow sufferers, for my knowledge remains with me, and with its help, I hope to get everything back again."

And so Fischer appealed to Razumovsky for administrative and financial help. And the indolent minister did nothing. Flynn writes: "Neither Kutuzov nor Razumovsky helped the university during the calamity of the French invasion in 1812. Razumovsky joined the Committee of Ministers, the army, and several other agencies in issuing orders to the university to close, or stay open; to stay in Moscow or evacuate…; to return to Moscow, or not return, and so on."

Fischer and the other professors therefore turned to the greatest of all supports their own bootstraps and self-help. By importuning local friends for money, gifts of books, and use of buildings, working their butts off, improvising, and even holding the equivalent of yard and bake sales, the professors managed to resume operations in September 1813, with a much reduced cadre of 129 students. By 1815, the library had reached 12,000 volumes (compared with 20,000 lost to the flames). Fischer himself spent the remainder of his career successfully rebuilding the great collections of his museum—with no help from Razumovsky. As late as 1830, he was still taking trips to Germany with explicit goals for replacing parts of the collection destroyed in 1812.

How then shall we taxonomize Europe for an optimal understanding of this complicated story about two noble brothers, their temperamental differences, and their beneficiaries, both actual and unrealized? The usual divisions of nations and languages don't seem to help much. Fischer was a German who worked in Moscow and published mostly in French. He wrote a dedication in Latin, hoping that a Russian nobleman would help to rebuild what the fire of French invasion had destroyed. Meanwhile, this nobleman's brother lived in Austria, where he knew Mozart and then acted for years as Beethoven's most significant patron.

I do not know how students and members of other disciplines—musicians, diplomats, patrons—would choose to parse this particular ball of wax. I can speak only from my own perspective as a scientist. My profession so often gets bad press for a variety of sins, both actual and imagined: arrogance, venality, insensitivity to moral issues about the use of knowledge, pandering to sources of funding with insufficient worry about attendant degradation of values. As an advocate for science, I plead "mildly guilty now and then" to all these charges. Scientists are human beings subject to all the foibles and temptations of ordinary life. Some of us are moral rocks; others are reeds. I like to

ink that we are better, on average, than embers of many other callings (although have no proof that we are) on a variety of sues central to the practice of good sci-ce: willingness to alter received opinion the face of uncomfortable data, dedica-on to discovering and publicizing our st and most honest account of nature's ctuality, judgment of colleagues on the ight of their ideas rather than the power their positions.

But on one issue, I do have confidence, sed on sufficient personal experience: in ience's adherence to a moral code not al-ays followed in other professions. Sci-ce does tend to be international. Most ientists happily share information, try rd to communicate with one another, d deplore the parochialisms that stymie ntact. (How, for example, can my field osper if paleontologists are not free to llect and study the fossils of their exper-se wherever they occur?) We all know merous stories of warm and continued operation between scientists in nations edicated to blasting each other off the ce of the earth. We have to work this ay, for knowledge is universal.

Jingoism may do no serious harm when expressed as boycotts of silk products, unofficial bans on German opera at the Met, or campaigns to change the name of a baseball team from the Cincinnati Reds to the Redlegs (yes, all these happened)—but science cannot and dare not ban a fact because colleagues in hostile nations discovered it. Fischer published his *Zoognosia* just a year after French aggression led to the holocaust of his lifetime's work, but he did not exclude the systems of Cuvier and Lamarck from his volume, for these Frenchmen were the world's greatest living taxonomists, and their work transcended the happenstance of their national origin. Fischer lost nearly all his books and specimens in the conflagration that almost destroyed Moscow and then spent the rest of his life restocking his collection for future generations of students, aided by the generosity of a large network of scientists—who donated, sold, or traded replacements—throughout Europe and the rest of the world. The boundaries of Fischer's world were not set at national or linguistic borders. His greatest impediment may have been an indolent and arrogant count, a countryman in his adopted land, who did not care, but whose brother in Austria served as midwife to some of the world's most glorious music.

The sciences of natural history have always been strong in their international solidarity and weak in attracting official support. Fischer discovered this for himself when Razumovsky wouldn't help, but scientists throughout the world pitched in. Fischer's own name should have taught him the virtues of self-sufficiency. The Austrian Razumovsky first met a great musician who included among his many names the weighty designation of Gottlieb (Theophilus, as he was christened in Greek; Amadeus as he later chose to render the name in Latin). They all mean "God's love"—and celestial powers surely adored Wolfgang Amadeus Mozart. The Russian Razumovsky was importuned by a fine scientist named Gotthelf, or "God's help." The count declined, but Fischer persevered and succeeded nonetheless—as he, no doubt, was meant to do, for Poor Richard told us that God only helps those who help themselves.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.



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New Days for Old Knights

Restorers rescue a Museum artist's mammoth masterpieces

About 1920, before there were any feature films that starred dinosaurs (the first was *The Lost World* in 1925), people waited in long lines at the American Museum of Natural History to see depictions of prehistoric animals created by Charles R. Knight (1874–1953). His small sculptures and paintings of dinosaurs and marine reptiles and his huge, panoramic murals of the Age of Mammals illustrated the grand sweep of life through the ages. Through Knight's artistry and informed imagination, the dry bones of extinct creatures came to life. Paleontologist Stephen Jay Gould—who, as a youngster, had been fascinated by Knight's artworks—recently wrote that Knight's paintings "established the image of *the* dinosaur for professionals and amateurs alike." And despite Knight's invisibility in scholarly publications, Gould credits him with "as much influence in paleontology as any scientist on earth."

All of Knight's outsized murals at the American Museum were created to loom over the massive skeletal mounts of extinct mammoths, giant sloths, and Irish elk. In 1911, at Museum president Henry Fairfield Osborn's behest, Knight designed four murals to be placed in the new Hall of the Age of Man, which featured the spectacular Ice Age mammal fossils. Delighted with the sketches, Osborn persuaded banker J. P. Morgan to foot the bills to keep Knight painting.

By 1917, Knight had completed his first mural series and had begun the second, illustrating Pleistocene life on different continents. During the next two years, he



In the early stage of restoration, this portion of Charles R. Knight's mural Mammoths in Winter *shows white canvas patches filling in gaps and tears. Old, discolored varnish gives the painting a yellowish tinge.*
AMNH

dded three panels to the Hall of the Age f Man and finished a new mural featuring ie extinct deer-moose and giant beavers a setting in ancient New Jersey. In 1921 e unveiled *Rancho La Brea Tar Pit,* a ural showing saber-toothed cats snarling ver trapped ground sloths in the bubbling sphalt of prehistoric Los Angeles. He so painted variations on that scene for ie Field Museum in Chicago and the Los ngeles County Museum (*see* "The Artist Vho Saw Through Time," by Robert M. eck, *Natural History,* August 1992).

In 1930 Knight completed a new series of four murals of Tertiary mammals, all set in North America, for what became the Osborn Hall of Late Mammals. Among the most spectacular was a scene of galloping titanotheres, giant rhinoceroslike creatures that were among Osborn's favorites—and the subject of his monumental monograph. These mammal murals, with their herds of ancestral horses and camels, titanotheres, and giant glyptodons have remained in place, one on each of the hall's four walls.

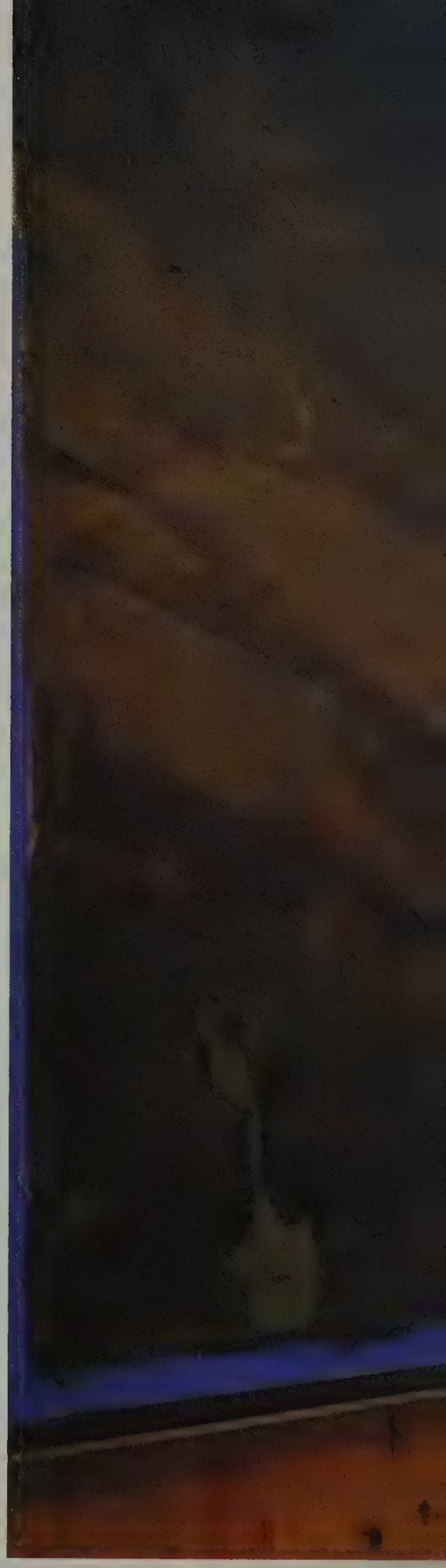
All the other murals, which had been restored and revarnished several times, were taken down in 1966 to make way for a new Earth History Hall. An outside contractor removed them from the walls, rolled them onto large wooden cylinders, and crated them for storage behind exhibits in the Hall of Early Mammals.

Five years ago, the Museum decided to remodel and expand the display areas of the entire fourth floor—a 57,000-square-foot space—at an estimated cost of $33 million. As part of overhauling the famous



After conservation, the mural is fully restored. Gaps have been filled in, damaged figures retouched, and the old varnish removed, revealing the painting's true colors.
MNH

Conservators Felicity Campbell and Marina Yashina retouch Autumn in New Jersey, Giant Beavers and Moose. *In the background are the chipped walls where Knight's murals originally hung.*
James Joern



Rancho La Brea Tar Pit, *depicting giant ground sloths and condors, required only a minimum of restoration.*
AMNH



dinosaur and fossil mammal halls, a renovations task force has been cleaning and rejuvenating all the paleontological treasures and remounting many of the skeletons. When the project is completed in 1996, Museum visitors will be able to walk through a huge, continuous exhibition of vertebrate evolution that will fill six halls. (The first remodeled exhibitions will be two halls of fossil mammals, scheduled to open in April 1994.) Many of the old standbys, such as the mounted skeletons of titanotheres, horses, and the Irish elk, familiar to generations of museumgoers, will be back. And so will Charles R. Knight's best murals.

The four mammal murals that had remained on the walls were given a surface cleaning to restore their freshness. But the rolled-up murals had deteriorated badly during their twenty-five years in storage, and experts were pessimistic about their future. "When we uncrated them," said conservator Felicity Campbell, who was hired to head the project, "they were as crumbly as cannoli. The murals had become so dried out and brittle, I doubted that they could ever be safely unrolled, let alone resurrected. In Knight's day, they had been glued to the wall with a very tenacious lead adhesive, and then, years later, virtually hacked off. There are still places on the wall where bits of the original canvas remain."

In 1990 the family of Museum trustee William S. Beinecke (through the Prospect Hill Foundation) contributed $250,000 to the cost of restoring some of the disintegrating murals. The contract went to a New York company called Art Preservation Services, headed by Steven Weintraub. Consultant Robert Sawchuck, working with Felicity Campbell, developed a detailed plan of action. Over the next two years, Campbell executed the meticulous restoration, assisted by contract conservators Yelena Budylina, Marina Yashina, and Elena Raposo.

Most of the preliminary work was done at a studio outside the Museum; later, the murals were set up in one of the empty halls for the final stages of restoration. First, the tattered murals were spread out on a large table at the conservator's studio. Visitors were sometimes surprised to find the restorers sitting on the backs of the unrolled artworks as they removed lead adhesive or repaired tears. However, that was the only practical way for them to reach the centers of the huge canvases.

"The real horror was the next step—lining the paintings," said Campbell. "That meant gluing the fragile, tattered originals to strong, new fabric supports. Heat and pressure were necessary to set the adhesive used for the linings. Since the paintings are nine by twenty feet, we had to construct a huge table with a vacuum-pressure device and heating system, which Robert brilliantly engineered. I don't know if it's ever been done on this scale before. The larger canvases had to be heated in thirds, as there wasn't sufficient electrical power in the studio to heat an entire sheet at once. When we unrolled the paintings for the first time, an industrial hygienist put us all in white Tyvec suits and masks to protect us from any lead dust that may have flaked off the paintings' backs."

One of the team's major difficulties was finding seamless pieces of lining fabric large enough to back the murals. Campbell and Sawchuck investigated materials made for awnings and sails, but finally decided on a double lining made of Reemay



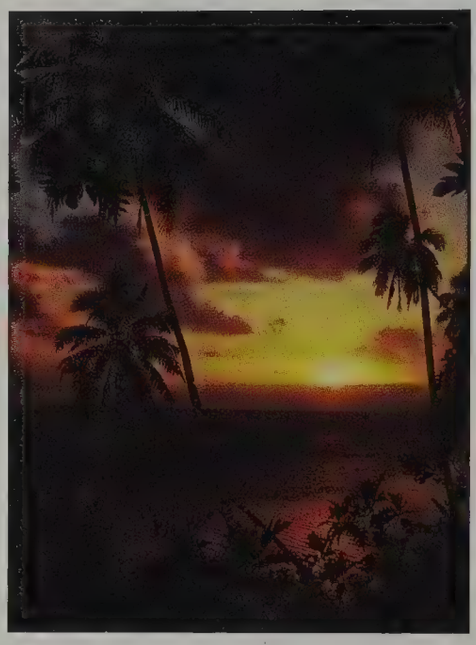
a stable, nonwoven polyester) and a semi-rigid polyester cloth. Reemay is manufactured in giant sheets that farmers spread out over fields to protect young plants from frost. "It's the same material you throw in your dryer to freshen clothes," Campbell explained, "and it is also used to stiffen collars. The polyester cloth is used in large paper-making machines." When the double lining was in place, the paintings were temporarily rolled onto cylinders; they were so heavy that they could only be taken out of the studio by a crane from a second-story window. At the Museum, they were mounted on reinforced plywood panel stretchers before the final restoration work could be done.

Now that the murals were relined and mounted, the restorers faced other serious problems. *Autumn in New Jersey, Giant Beavers and Moose* was full of tears, holes, and missing strips. New patches had to match the original surface, down to the weave of the canvas. Using silicone, Campbell made molds of the painting's surface, then spread thin layers of a wax-and-resin compound over the gaps, and finally ironed on the silicone impressions of the canvas texture. With the surface even, the missing parts of the composition were reconstructed using paints made from hand-ground pigments in a modern synthetic medium.

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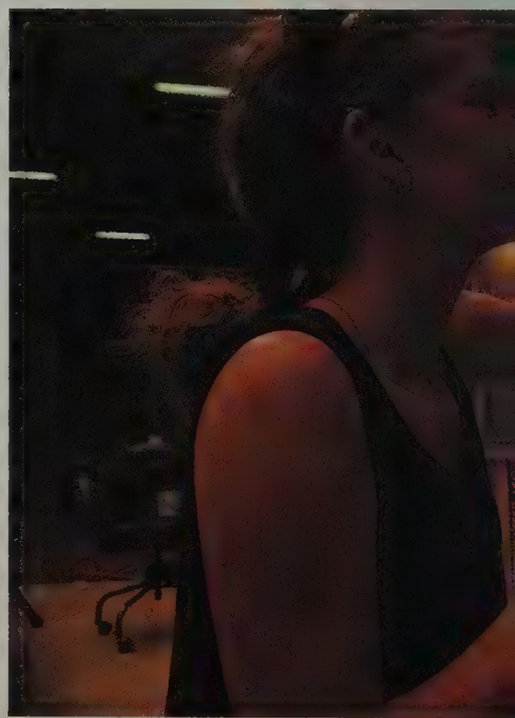
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Yashina retouches an animal figure with hand-ground pigments.
James Joern

Intimate involvement with the paintings, down to the brushstrokes, gave the restorers an appreciation of Knight's skill. "He was more than an animal painter or anatomist or illustrator," said Campbell. "After the paintings were cleaned, we were able to see that he was an acute observer of light effects." Knight meticulously determined where the shadows should fall. He sculpted clay models of the prehistoric creatures and then observed the play of sunlight on them. In some paintings of groups, he used the same animal model painted from different angles.



In depicting the woolly mammoths, Knight used not only the mounted fossil skeletons for reference but also copies of the paintings and engravings left by Ice Age cave artists in France. All of the engravings and paintings of mammoths by these artists of 15,000 years ago are in precise agreement with one another on the high hump on the forehead, the notch between the hump and the neck, and other anatomical details. In 1927, Knight visited the French caves to see the paintings for himself. He wrote of gazing at the mammoth and reindeer images "with unalloyed enthusiasm and astonishment" and with "a distinct feeling of awe and admiration for the skill of the man who had painted [them] thousands of years ago."

Campbell found that Knight's palette "tended to be impressionist. He used light pastel colors and specifically chose a coarsely woven canvas so that he could delicately brush over the tips of the weave with an almost-dry brush to achieve the subtlest lighting effects. I strongly suspect that when he finished, he left the paintings unvarnished."

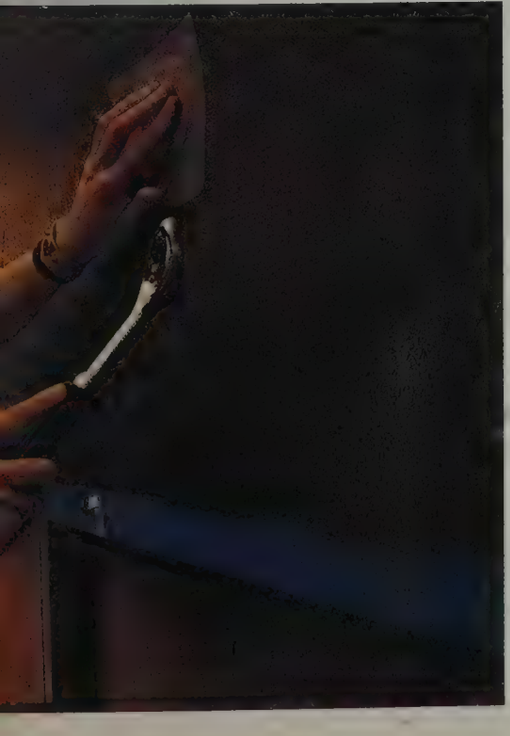
Some time later, Campbell believes, someone varnished the murals with an unknown material that had yellowed substantially; the blue snow beneath the woolly mammoths looked more like a green golf course. Standard solvent mixtures failed to remove the discolored layer, so the conservators developed a technique of swelling it with solvent vapors, then painstakingly rubbing it off.

Years ago, someone had attempted a partial restoration of some of the murals, but the overpainting was crudely executed and had to be entirely stripped off. In one instance, a torn reindeer was transformed by the earlier restorer into a tree, a simpler task than reconstructing the animal figure. Campbell, following Knight's original, turned it back into a deer. The previous restorer had also added a beard to a mammoth; this detail, not in Knight's original, was also removed.

Three of the murals that languished in storage were too badly damaged to be rescued within the present budget. Of the original group, however, *Reindeer and Mammoths in Winter on the River Somme* (1916), which measures nine by fifty feet, has been completely repaired, restored, and remounted in the refurbished Osborn Hall. Two of the subsequent works, *Rancho La Brea Tar Pit* and *Autumn in New Jersey, Giant Beavers and Moose,* have also been successfully brought back from near-extinction and remounted in the Osborn Hall to delight new generations of Knight fans.

Richard Milner

Using a heat wand, Campbell impresses the texture of the original canvas onto a new patch.
James Joern



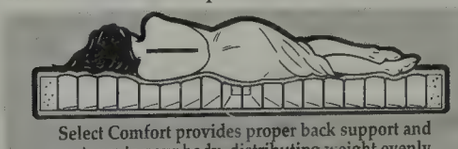
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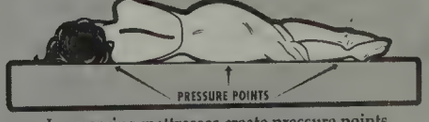


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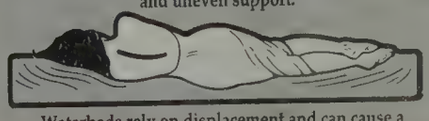
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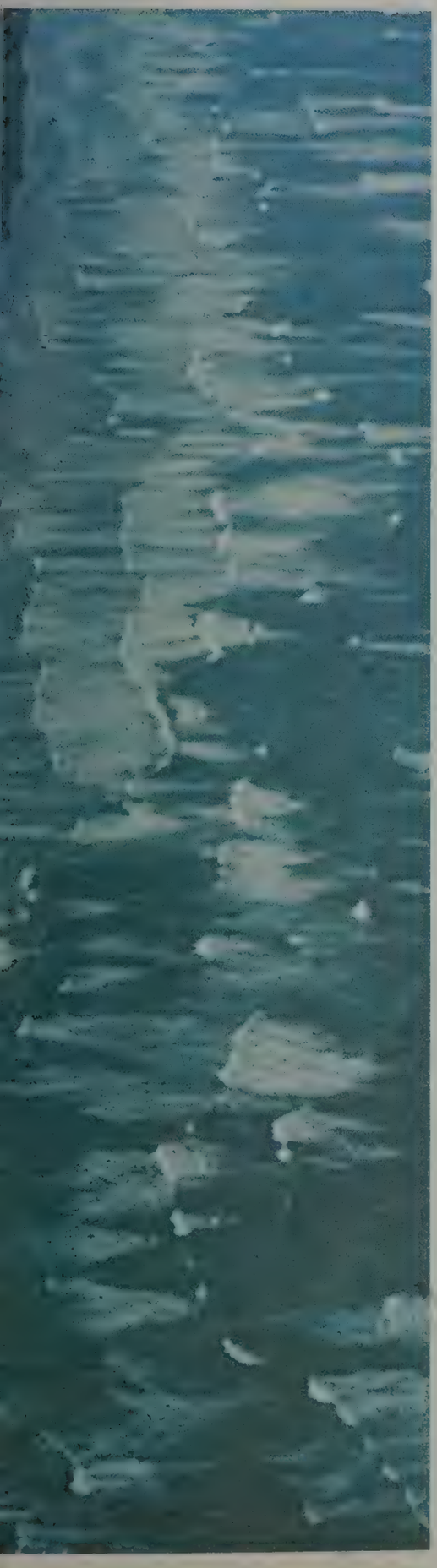
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The mouth of the Nariva River parallels Trinidad's east coast. Along the banks grow mangroves and coconut palms.
Photographs by Roger Neckles



Nariva Swamp, Trinidad

by Robert H. Mohlenbrock



Shaded by thousands of coconut palms, the road along Trinidad's east coast from Lower Manzanilla to the small village of Plaisance is seldom more than a few feet from the green-blue waters of the Atlantic Ocean. A golden sand beach stretches invitingly alongside the seventeen-mile route, but swimming is dangerous because of the strong undertow. West of the road lies 100-square-mile Nariva Swamp, whose fresh water contrasts with salty Caroni Swamp on the island's west coast. Nariva Swamp is fed by freshwater streams, such as the Navet and its tributaries, which flow eastward from the Montserrat Hills. Bordering its eastern edge is the Nariva River, whose brackish waters favor the growth of mangroves.

More than fifteen square miles of the swamp were set aside as the Bush Bush Wildlife Sanctuary in 1968. In places, it is wild and woolly, with standing water present all or part of the year. The few trails that lead inside become quickly overgrown. Red-bellied macaws come to roost in the moriche palms in the evening, and wattled jacanas swim around mats of water hyacinths. Yellow-headed caracaras, moriche orioles, and silvered antbirds regularly frequent the swamp. The plant life is equally exotic and represents a variety of wetland habitats.

A very small portion of Nariva Swamp, particularly in the northeast corner, is dominated by swamp bloodwood, a huge tree with red sap. It is a member of the legume family, producing pods shaped somewhat like thin flying saucers, with the seeds in the center. The leaflets of the bloodwood taper to an exaggerated point, known as a drip tip, characteristic of many trees in tropical rain forests. During the rainy season, water droplets readily fall from the leaftips to the ground below, where they can be absorbed by the roots.

Most of the bloodwood groves lie on the northern edge of the swamp, where the ground is flat and covered with fresh water for all or most of the year. The base of these giants is markedly swollen or buttressed to give stability in the saturated terrain, while the diameter at shoulder height may be as much as four feet. The trees form a closed canopy about sixty feet above the ground, allowing little light to penetrate. A few philodendron species grow on the branches of the bloodwood trees, but the understory is mostly open, with a few vines and some small thickets of shrubs.

On the seaward side of Nariva Swamp, under the influence of wind that blows in from the sea, grows an extensive palm swamp dominated by palmiste, a tree related to the royal palm of Florida. This palm has leaves up to twelve feet long and may reach one hundred feet in height, forming a patchy canopy full of gaps. A jungle of vegetation, including many shrubby species and trees up to sixty feet tall, grows beneath the palmistes in the abundant sunshine that comes through the trees. The most common shrubs in the understory are two species of seaside mahoe (related to temperate-zone hollyhocks) and the spiny-trunked *Bactris,* a palm known locally as black roseau. Beside these often grows the giant, red-and-yellow wildflower known as lobster claws (a species of *Heliconia*).

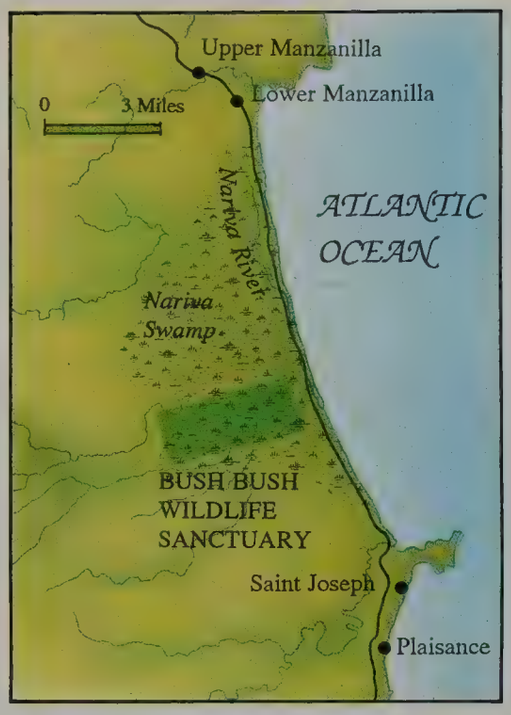
The soil of the palmiste marsh is flooded throughout the year, although the water level drops during the dry season, from January to April. Sometimes a palmetto, a shrubby palm, grows beneath the tree palms, forming erect, woody, cone-shaped "knees" similar to those produced by bald cypress in the southeastern United States. These structures, called pneumatophores, were once thought to help the plant breathe, but apparently their purpose is to store large amounts of starch.

Another type of palm marsh occurs on the western side of Nariva Swamp, farthest from the influence of the sea. This marsh is dominated by the moriche palm, which reaches a height of eighty feet.

Although bloodwood and palm swamps are scattered throughout Nariva, much of the swamp (where the water is deepest) is dominated by giant, nonwoody plants—sedges, grasses, and ferns. Most grow to a height of twelve feet, and all of them form thick, extensive underwater root networks

Joe LeMonnier





Nariva Swamp

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that enable them to spread into dense, pure stands that exclude most secondary species. If a dry-season fire damages trees in a palm marsh, the fast-growing herbs and ferns will temporarily invade.

The principal giant herbs are a flat sedge (related to eastern United States nut sedge); a grass known as wild cane; and a wildflower with a nearly woody stem that is related to philodendrons and, like them, bears flowers enclosed in green, leafy structures. The most widespread fern is golden acrostichum, which has three-foot leaves. In the deepest water grows still another kind of grass, related to the cut-grass of the eastern United States.

In addition to its other showy plants and animals, Nariva Swamp is home to two of the most bizarre amphibians in the world. One is the paradox frog, which lives in the Amazon River system of northern South America and on Trinidad. The adult frog, with its yellow-and-black-striped legs and exceptionally slippery skin, reaches a length of about three inches. It lives in shallow water, stirring up the mud with its long, slender toes and fingers to keep the water around it sufficiently oxygenated. The unusual feature, the paradox, is that the tadpole that metamorphoses into this three-inch frog is nine or ten inches long.

Equally fascinating is the Suriname toad, which lives in northern South America and Trinidad and, like many frogs, spends its entire life in water. The female of this species carries the developing eggs in pouches on her back, where the embryos complete their metamorphosis from tadpole to toad before emerging. Western scientists first encountered the Suriname toad nearly two centuries ago, but for a long time they did not know how the eggs got on the female's back.

In 1960, amphibian experts George and Mary Rabb of the Chicago Zoological Park (Brookfield Zoo) observed a pair of Suriname toads mating in an aquarium at the zoo. At the bottom of the tank, the male clasped the female tightly from behind, with his chin pressed firmly on the skin of her back. The two embracing toads ascended as if going up for air, doing a backward somersault without breaking the water surface. They then paused momentarily in an upside-down position before returning head-first to rest at the bottom of the tank. They carried out this maneuver eight times.

Beginning with the ninth time, eggs started to appear, three to five at a time, on the female's back. The eggs were laid, usually at the midpoint of the somersault, when the female was belly-up. The eggs were apparently then caught in skin folds of the male's belly as he curved his body during the somersault. The eggs thus were shepherded between the male's belly and the female's back, the close embrace preventing them from rolling away. When the toads righted themselves at the bottom of the tank, the eggs dropped onto the female's puffy back and stuck there.

During the first day, the eggs sank deeply into the female's skin, and after two days, they were hidden below the skin surface. Seventy-seven days later, the Rabbs observed a forelimb projecting from one of the pouches, and shortly thereafter, the young toadlets began popping out of the mother's back and into the water.

This month, Robert H. Mohlenbrock takes a holiday from his usual beat, the 156 U.S. national forests. Professor emeritus of plant biology at Southern Illinois University, Carbondale, Mohlenbrock is chairman of the North American Plant Specialists Group of the Species Survival Commission, International Union for the Conservation of Nature.



A little hermit hummingbird perches on a flower called lobster claws.



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Omaha Dance Lessons

Who says Tonto never laughed?

by Roger L. Welsch

Antonia (our nine-year-old daughter): "Hey, Dad, guess what!"

Me (gullibly): "What?"

Antonia: "Chicken butt!" (Collapses in laughter. Regains control finally.) "Guess who!"

Me (suspiciously): "Who?"

Antonia: "Horse doo-doo!" (Uncontrollable, hysterical howling.) "Dad, guess why!"

Me (with increasing pain): "Why?"

Antonia: "Cow pie!" (Unable to continue because of laughter spasms.)

As I have observed in this column before, humor is not universal, gooey sentiments to the contrary. Age is one determinant, and we all accept that, which probably explains why the next generation is permitted to survive situations like the above.

Dee and Harriett, the two women who run the local cafe here in Dannebrog, have both been married (Dee still is) and they love men, so it's not (nudge nudge) one of those things. But they have accumulated back there in the kitchen a formidable archive of humor about men. They have Xeroxed lists of reasons why cucumbers are better than men, why men are inferior to women, and why men wear pants, none of which makes any sense to me. (For example,"Why are there female astronauts? Because if a crew gets lost in space, men are too stubborn to ask for directions." "What's the difference between E.T. and a man? E.T. called home." "What did God say after He created man? 'I can do better than this.' ") The information Dee and Harriett give me is useful, however, when us guys get together and laugh about why it is that women have no sense of humor.

I was raised a city boy, and I know I am still oblivious to a lot of the humor that I hear now that I have moved to the rural Plains. Trying to fit in, I laugh and smile and shake my head when my farmer friends conclude a long tale with a line like, "So he drops the combine snoot, not remembering that it's set for milo, mind you [uncontrollable laughter], and tears into that bean field...and don't forget, this is the same guy who's already wrecked his swather on a stump...!"

One rural punch line I do appreciate was so subtle that I nearly missed it. I was in a conversation with a farmer and several agricultural science types, if you know what I mean. We were talking about the effects of drouth (as we refer to it) on crop yields. I didn't understand much of what I was hearing, but I had a pretty good idea from the looks on their faces, and I, after all, was living through the trials of the drouth myself. Finally the academics turned to the farmer. "What has the drouth done to your crops?" they asked solicitously.

"Well," he drawled. "The corn crop hasn't been as good as expected, but then no one thought it would be." The ag-scientists continued their conversation in a flurry of statistics. If the farmer hadn't winked at me, I probably wouldn't have realized that I had just heard a joke—my favorite rural joke ever since.

Are there city jokes farmers don't understand? Of course. Watch any television show. The media are dominated by urban humor. Farmers don't understand Eddie Murphy or Andrew "Dice" Clay. Period.

Language is another factor in humor confusion. My father is a terminal German, and although his primary language is English, there are times when he forgets that. At Thanksgiving dinner, he loves to rock back in his chair at the conclusion of the feast and deadpan, "Well, we've made a duck out of the turkey!" Then he looks around and waits for the laughter. Instead, my children and any guests look at one another and shrug their shoulders, the sensitive among them trying to reestablish the conversation so Grandpa is not embarrassed by his own goofiness.

Every year it falls to me to explain that he used to say, back before the Big War, when German was still an acceptable language, "*Nah, wir hab'm 'n Ent' aus dem Huhn gemacht,*" which ostensibly means, "Well, we've made a finish [*Ende*] of the turkey," but as pronounced comes out, "Well, we've made a duck [*Ente*] out of the turkey." It's not great humor, but it's my father's humor.

The presumption is always that we laugh at what's funny; the other guys laugh at dumb stuff. Or they don't have a sense of humor at all. Like Native Americans, famous for never cracking a smile. Tonto never laughed, right? (Well, okay, maybe that time he said, "Look out, Masked Man, don't step in that pile of kemosabe." Which may be why the Lone Ranger called him Tonto, Spanish for "stupid.")

Actually, Native Americans do have a sense of humor, which is pretty remarkable, considering. Alice Fletcher, a respected ethnologist of the Omaha, described, in an article entitled "An Evening in Camp among the Omahas" (*Science,* July 1885), a nineteenth-century campfire scene to which she had been privy:

> We had just finished our supper in the long conical shadow of the tent; and, the dishes being disposed of, we settled ourselves for

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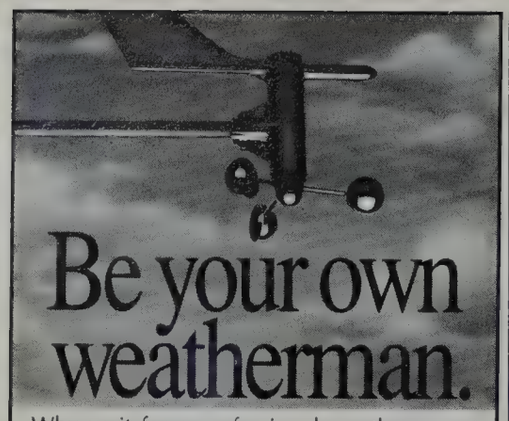
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the evening chat. While Ma-wa-da-ne was filling his pipe, the other four men disposed themselves comfortably preparatory to the enjoyment of the smoke. Te-me-ha, with her usual industry, had spread upon her lap the brilliant-colored porcupine-quills with which she was embroidering a pair of moccasons, while old Me-pe sat rocking to and fro, dividing her attentions between the gay-colored quills and the fringe of my wrap. After the ceremonial round of the pipe, I said to the men,—"You do your share in this embroidery, since you capture the porcupine. Tell me about hunting them."

Fletcher may have been interested in porcupine quills, hunting, and embroidery, but she was also priming the story-telling pump. According to her brief account of this rustic evening, her strategy worked. She got a story about gathering quills. But she also got others, some of them suggestive of Omaha humor:

When I was young [here the old men shouted, but the young man with a merry twinkle in his eye went on], I was very observing. One day I was looking about me, near the slough back of father's, when I noticed a frog hopping very fast. Suddenly he stopped, picked up a stick three or four inches long, and turned, holding it firmly in his mouth. I saw he was being closely chased by a water-snake who tried to swallow the frog, but the stick in the frog's mouth caught in the jaws of the snake. Several times the snake withdrew, and tried to attack the frog from the rear; but he would jump around, and immediately face the snake again. This happened several times; and at last the snake got tired, and slipped off in the bushes, leaving the frog victorious.

This humorously unbelievable story prompted one of the other men to offer this tale:

Once in the fall, Badger and I went hunting along the Loup River. We were afoot. We started up several elk, ran them down, and killed one. While I was butchering, Badger returned to camp for a pony to bring in the meat.

After I had skinned the animal, and piled the cuts of meat on the skin, I lay down nearby in the tall grass, and fell asleep. I was awakened by the sound of footsteps. Rising cautiously, I saw a large gray wolf standing near the meat. When he espied me, he began to growl, showed his teeth and all the hair on the back stood up. Taking my gun, I leveled it at him, and shot. He was a fine fellow, and, as he fell, I determined to have his skin at once. It was the work of a few moments to flay him. As I threw his skin to one side, the legs of the wolf began to twitch, and the blood to trickle. In a moment the wolf was on his feet, and walking off without his skin.

Fletcher's fireside evening with the Omahas drifted off with stories about hunting and pets and all the sorts of things that real story-telling sessions include. What has always impressed me about this century-old narrative of narratives is that it illustrates precisely how things go today during evenings among the Omahas. Or farmers up at the Chew 'n' Chat Cafe. Or among the Taureg or Aleuts or stockbrokers, I suppose.

Of course, when I first encountered the Omaha, thirty-five years ago, I didn't understand a lot of their laughter. For example, we would be playing the traditional Omaha hand game, a hundred or so of us, in the old Lincoln City Swimming Pool bathhouse, a big open space, just what the hand game requires. I don't want to get tangled up in the details, but the Omaha hand game is a community-team game with music, food, dance, and a lot of meaning. It is a little like Button, Button, Who's Got the Button? but a good deal more complicated.

Now and then someone would be doing a thoroughly miserable job of guessing (more often than not it was me) and some joker would rattle the chain on one of the bathhouse showers. And everyone—the Omahas anyway—collapsed in laughter. What was that all about? Since I knew it was a discourtesy in Omaha culture to ask questions, I carried my ignorance in silence, something of a custom among *my* people, now that I think of it. Eventually an Omaha friend took mercy on me and explained that bad luck is understood to be the result of insufficient bathing. Great. I was a lousy guesser because I was a *lousy* guesser.

The gourd dance, which takes place five or six times during the hand game, often offers another opportunity for laughs. A representative of the winning team hands gourd rattles to two members of the losing team, and those two are expected to dance and to give, through the voice of a "crier," a sacrifice, gift, or consolation of some kind—a dollar to the game stakes, a gift to a friend, five dollars to someone who has traveled a long distance, a horse to a respected elder. The gift is not so much a penalty as an opportunity, since within Omaha culture, gift-giving is a source of prestige.

Sometimes the person who is given the gourd chooses not to dance, although he or she always gives a gift. There may be a special reason for this—the chosen person may be in mourning or there may be an illness in the family or he or she simply may not be inclined to dance. In any case,

someone almost always gives money immediately afterward or later in the evening, announcing that the money is to pay "for dance lessons" for the reluctant individual. This never fails to make the Omaha collapse in hysterical laughter.

Why? Well, just as it is a discourtesy in Omaha culture to ask a question, it is offensive to give directions, lessons, or orders (talk about a cultural jolt for an ethnic German!). The joke in money for lessons is the very idea of "lessons." Among the Omaha you learn by observing and doing. Lessons are the white man's idiotic way. To learn to dance Omaha dance, you dance Omaha dance. You either do it or you don't. The very idea that you could take lessons in Omaha dance is a hilarious oxymoron.

My recent favorite Omaha joke combines a very modern context with a distinctly traditional foundation. A white man is driving through the Omaha reservation when his car breaks down. He opens the hood and starts working on the reluctant engine but is short a necessary tool, so he walks to an Indian house just off the highway. He approaches the shack where a dozen or so kids are playing in the front yard—fighting, laughing, jumping, singing. The white man yells to the old Omaha sitting on the sagging porch, "Hey, Geronimo, do you have a monkey wrench?"

"Monkey ranch?" the old man laughs. "No, these are my grandkids."

That is not just a pun or a linguistic error. A central spiritual figure of cosmic consequence among the Omahas is Icktinike, the Trickster—part god, part man, part animal, fool, hero, genius, idiot, terribly powerful, painfully vulnerable. I have heard again and again from Omahas the story about the first time an Omaha saw a monkey in a nineteenth-century traveling carnival. The immediate response of the Omahas was "Icktinike!" Having never seen a monkey, having never seen Icktinike, they all agreed: the monkey is Icktinike; Icktinike is a monkey.

So the white man was not simply asking the old man if the children were monkeys, or like monkeys, but if they were perhaps something of Icktinike. Well, yes and no, the old man has to admit. They are monkeys and they are divine, these God-given children, but are they Icknitike? Well, that is a much more complicated issue, since there is something of Icktinike in all of us.

Folklorist Roger L. Welsch lives on a tree farm in Dannebrog, Nebraska.

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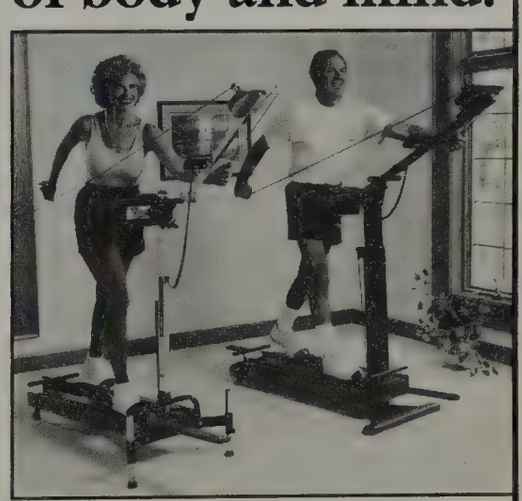
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At the American Museum of Natural History

Man and Nature Lectures

Early in his career, Charles Darwin developed theories about Earth's origins that later coalesced into a fascination with the origin and development of species. In this year's Mack Lipkin Man and Nature Lectures at the American Museum of Natural History, Frank H. T. Rhodes, president of Cornell University, will talk about the evolution of Darwin's thinking in the course of his career. The lectures, on Monday and Tuesday, October 25 and 26, will begin at 7:00 P.M. in the Main Auditorium. Advance admission for the series is $20 ($10 for members), and tickets may be ordered from the Office of Special Events, American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024-5192. Call (212) 769-5019 for further information.

Margaret Mead Film and Video Festival

Sixty films, selected from more than 350 submissions from around the world, will be shown at this year's Margaret Mead Film and Video Festival. Featured will be the films of Timothy Asch, who has spent the past three decades filming the Yanamamö of the Amazon Basin, as well as various Indonesian communities on Bali and Flores Island. Opening Monday, October 4, the festival will run through Sunday, October 10. For a complete schedule, call (212) 769-5305.

Interpreting the Dead Sea Scrolls

The 2,000-year-old documents known as the Dead Sea Scrolls were discovered in 1947 in caves bordering the Dead Sea. Robert Eisenman, professor of Middle East religions at California State University in Long Beach, will talk about the importance of the recently published facsimiles of the scrolls. The lecture will be held on Tuesday, October 19, at 7:00 P.M. in the Kaufmann Theater. Tickets are $25. Call (212) 769-5305 for a complete schedule of fall lectures.

From Belz to Brooklyn: The Hasidim

In the eighteenth century, Rabbi Israel ben Eliezer, known as the Baal Shem Tov (Master of the Good Name), taught that there were no divisions between the sacred and the secular, a philosophy that came to be known as Hasidism. Today the world's largest concentration of Hasidim live in three small Brooklyn communities. Yale Strom, author of *The Hasidim of Brooklyn: A Photo Essay,* will give a slide- and music-accompanied lecture on Monday, October 18, at 7:00 P.M. in the Kaufmann Theater. Tickets are $25. For further information about fall lectures, call (212) 769-5305.

Antarctica Exhibition

The world's southernmost continent will be the subject of a Museum exhibition, "Antarctica," from Friday, October 22, through Monday, January 2, in Gallery 3. The exhibition will focus on this last great wilderness and its role in global climate. Penguin dioramas, video and audio programs, three-dimensional models of antarctic ice, and objects used by people who have lived and worked in Antarctica will be featured.

War of the Worlds

On the night before Halloween in 1938, thousands of Americans listening to Orson Welles's broadcast of H.G. Wells's *War of the Worlds* believed that Martians had landed in New Jersey. On Saturday, October 23, the 1953 film based on Welles's book will be shown in the Linder Theater at 4:00 P.M. Introducing the film will be Brian Sullivan, the Hayden Planetarium's designer of special effects. For more information, call (212) 769-5606.

Alexandra David-Neel

In 1924, the Frenchwoman Alexandra David-Neel entered the forbidden city of Lhasa, Tibet, disguised as a beggar. A portrait of this traveler, explorer, feminist, opera singer, and writer—who lived to be 101 years old—will be presented by Barbara and Michael Foster, authors of *Forbidden Journey,* a 1989 biography of David-Neel. This program will take place on Sunday, October 24, at 3:00 P.M. in the Kaufmann Theater. Call (212) 769-5606 for ticket availability.

Ghost Stories

Storyteller and folklorist Laura Simms returns to the Museum for her twenty-fifth year to recount legends, myths, and true-life adventures. Traditional tales from Tibetan Buddhist lamas, Maori elders, and Native American storytellers will be presented on Friday, October 29, at 6:00 P.M. (family program for ages five to twelve) and at 8:00 P.M. (adult program). Call (212) 769-5606 for additional information.

The Universe's First 100 Seconds

How new ideas about the possible beginnings of time and space can help us understand the nature and fate of the universe will be the subject of an illustrated



A scene from Madame l'Eau, *a film in the Margaret Mead Film and Video Festival*

talk by Thomas Bania of Boston University. The lecture, part of the Frontiers in Astronomy and Astrophysics series, will be given on Monday, October 25, at 7:30 P.M. in the Sky Theater. Tickets are $8 ($6 for members). For information about this and other Planetarium events, call (212) 769-5900.

GEOLOGY OF THE PLANETS

Planetary discovery and our expanded knowledge of the solar system in the last thirty years will be the subject of talks by Sidney S. Horenstein, coordinator of the Museum's environmental programs, on four consecutive Thursday evenings. On October 21, he will discuss the origin of the solar system, meteorites, and the dynamic earth; on October 28, the moon, Mercury, and the asteroids; on November 4, Venus and Mars; and on November 18, Jupiter and Saturn and their moons, as well as Uranus, Neptune, and Pluto. Tickets for the series are $35. For a complete schedule of fall lectures, call (212) 769-5305.

GLOBAL CULTURES IN A CHANGING WORLD

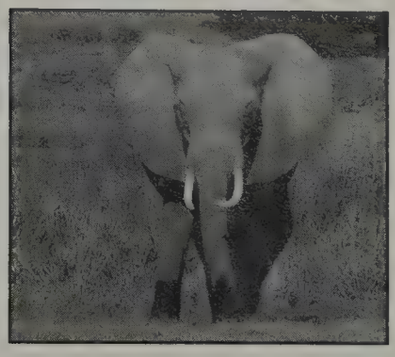
From October 1993 through June 1994, the Museum's education department will offer lectures, films, workshops, and music and dance demonstrations to celebrate diverse cultural groups and their traditions in a changing world.

October marks India's ten-day autumn festival, celebrating the Mother Goddess's victory over evil. Beginning Thursday, October 7, and continuing until Saturday, October 16, the festival will be held in the Charles A. Dana Education Wing and will include folk dance workshops, classical music of South India, the works of India's contemporary visual artists, and Indian foods. The programs are free with Museum admission. Call (212) 769-5315 for a complete schedule.

These events take place at the American Museum of Natural History, Central Park West at 79th Street in New York City. The Kaufmann and Linder theaters are located in the Charles A. Dana Education Wing. The Museum has a pay-what-you-wish admission policy. For more information about the Museum, call (212) 769-5100.



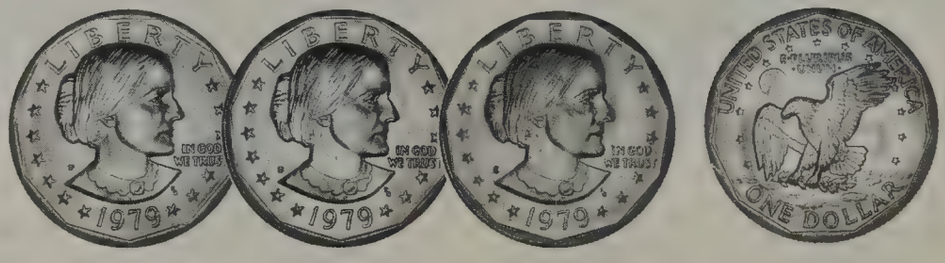
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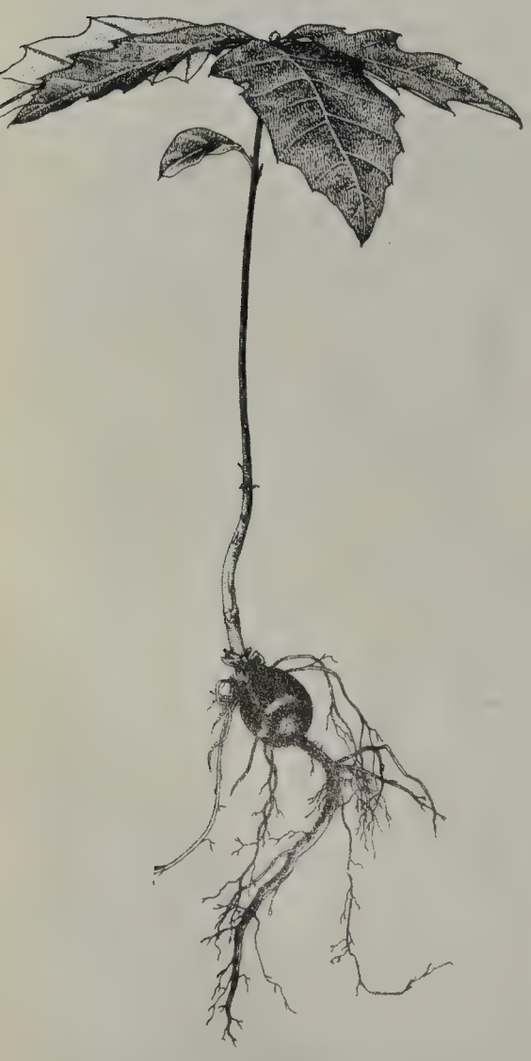
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The Forest in the Seeds

by Barbara Kingsolver

In the spring of my first year as a graduate student in ecology, I had my first taste of real biological field research. It involved sitting in a mesquite thicket in the southern Arizona sun, watching a species of territorial lizard do, quite frankly, almost nothing. It was stultifying. When I signed on as a rookie animal behaviorist, I had been thinking of Konrad Lorenz's curiously malimprinted ducks and of Imo, the genius macaque that introduced grain winnowing to her tribe. Visions of sandhill cranes danced in my head. And I had washed up instead in the land of torpid lizards. I could only be grateful that my subjects at least had heartbeats, and pity my botanically inclined colleagues who were counting pollen grains under a microscope or literally watching the grass grow.



Red-oak seedling, an illustration from Faith in a Seed
Abigail Rorer

Nature does not really move in mysterious ways. She just moves so slowly that we're inclined to lose patience and stop watching before she gets around to the revelations. The natural historians of the nineteenth century knew this. They had no reason to expect bells and whistles, and they had the luxury of writing for an audience with time on its hands. Charles Darwin charmingly suggests as much in his introduction to *The Origin of Species*: "It occurred to me, in 1837, that something might perhaps be made out of this question [of the origin of species] by patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on it." Twenty-two years later, he had reflected on everything from slave-making ants to the Greenland whale and had set it all down on paper, and for any reader willing to spend a portion of a lifetime with it, the book remains a thorough masterpiece.

Henry D. Thoreau, Darwin's contemporary, shared the penchant for accumulation and reflection, and while he did not shake the scientific paradigm so profoundly, he brought to his work an expansive poetic sensibility. Modern readers who have finished all the Thoreau that's in print (and those who have not) can quietly rejoice that Bradley P. Dean has compiled, from the massive notebooks of Thoreau's last years, a collection of his previously unpublished writings, *Faith in a Seed.*

The book, with a scholarly introduction by Robert D. Richardson, Jr., and an engaging foreword by Gary Paul Nabhan, contains fragmentary treatises on wild fruits, weeds and grasses, and the succession of forest trees. But the centerpiece is Thoreau's last important manuscript, *The Dispersion of Seeds,* in which the author meticulously noted methods of seed ripening and dispersal, germination, and growth of a great many species: pines, willows, cherries, milkweeds, eight kinds of *Desmodium,* and virtually every other plant known to the neighborhood of Concord, Massachusetts. With a categorical thoroughness akin to Darwin's, Thoreau intended to prove his conviction—still in dispute at the time—that new plants do not spontaneously generate but, rather, grow always and only from seeds.

While the energy he brings to this argument may now seem quaint for its obsolescence, there is something wonderful to be gained from a 200-page walk through the woods with a scientist from a century and a quarter ago. Thoreau had just read *The Origin of Species,* and was clearly moving away from the travelogue format of his

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FAITH IN A SEED: THE DISPERSION OF SEEDS AND OTHER LATE NATURAL HISTORY WRITINGS, by Henry D. Thoreau. Edited by Bradley P. Dean. *Island Press, $25.00; 284 pp., illus.*

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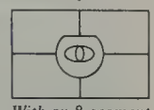
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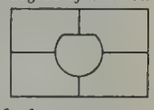


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"excursion" writings toward an articulation of unifying principles; he was attempting to see the forest among his trees. In his observations of plant communities, he touched on succession, allelopathy, and other concepts that would not have names until the birth of the science of ecology in the next century.

But his gifts as a writer transcend his contributions to natural science. Thoreau dismisses the notion that poetry and science are incompatible and recovers for his readers the simple wonder we hastily leave behind in the age of positivism. "How impatient, how rampant, how precocious these osiers," he writes. "Some derive their Latin name *Salix* from *salire,* 'to leap,' they spring up so rapidly—they are so salient. They have hardly made two shoots from the sand in as many springs, when silvery catkins burst out along them, and anon golden blossoms and downy seeds, spreading their race with incredible rapidity."

He admires the trees for their ingenuity and praises the wind that catches their seeds for its unfailing providence. He carefully watches the ways and means of the seed-scattering squirrels, foxes, birds (including, nostalgically, the ivory-billed woodpecker), a wading moose or cow or "a wading pickerel fisher of the old school, who does not mind if his clothes be wet," and even little boys, who blow off the seeds of dandelion heads to find out whether their mothers want them. ("If they blow off all the seeds at one puff, which they rarely do, then they are not wanted.")

The pace of the book is leisurely. The margins sparkle with Abigail Rorer's illustrations of seeds, and I found myself unconsciously turning down the corner of nearly every other page to note an arresting moment of prose. The book's greatest appeal is the man himself. As a transcendentalist, Thoreau understood that the scientist and the science are inseparable, and he insinuates himself into his observations in a way that modern science writers, we virtuosos of the passive voice, have been carefully trained to forsake.

"I went forth on the afternoon of October 17th," one section begins, "expressly to ascertain how chestnuts are propagated." The chestnuts are now as dead as the ivory-billed woodpeckers, but still we can watch this bearded, wide-eyed man—who will within two years be dead himself—inhaling an autumn day and focusing his powers not only on the chestnuts but also on his own heart and the folkloric tenor of his village.

A squirrel goes a-chestnutting perhaps as far as the boys do, and when he gets there, he does not have to shake or club the tree, or wait for frost to open the burrs, but he walks up to the burrs and cuts them off and strews the ground with them before they have opened.... The jays scream and the red squirrels scold while you are clubbing and shaking the chestnut trees, for they are there on the same errand, and two of a trade never agree.

In another passage he exclaims:

Consider what a vast work these forest planters are doing! So far as our noblest hardwood forests are concerned, the animals, especially squirrels and jays, are our greatest and almost only benefactors.

But what is the character of our gratitude to these squirrels?... Are they on our pension list? Have we in any way recognized their services?... We should be more civilized as well as humane if we recognized once in a year by some symbolical ceremony the part which the squirrel plays in the economy of Nature.

Faith in a Seed is infused with Thoreau's delight, his meticulous curiosity, and his inspiring patience. Across the silence of 125 years, during which an unforeseeable glut of hurry has descended, he exhorts us to slow down and take notice, to learn how to watch seeds become trees. This book is the sort that should be forced on students, probably against their will. When I recall my lizard-watching days, I sympathize with their restlessness. Recently, during a lecture to a college class on writing and environmental activism, a student asked me, "Why can't we just teach people about this stuff in TV commercials?" The question was both naïve and astute. As a nation we won't defer to the spotted owl (let alone declare a National Squirrel Holiday, as Thoreau suggested) until we are widely educated, but the things we must know—notions of food chain and habitat and the ways all species depend on others—are complex ideas that resist reduction. Evolution can't be explained in a sound bite.

Our culture trains us daily in impatience. Even well-intentioned educational endeavors, such as time-lapse photography, carefully edited nature films, and the easy access to exotic animals offered by zoos, lead us to expect nature to be all storm and no lull. It's a dangerous habit. Natural history writer Robert Michael Pyle asks: "If we can watch rhinos mating in our living rooms, who's going to notice the wren in the back yard?"

The real "Wild Kingdom" is as small and brown as a wren, as tedious as a squirrel turning back the scales of a pine cone to capture its seeds, as quiet as a milkweed seed on the wind—the long, slow stillness between takes. This, I think, is the message in the bottle from Thoreau, the man who noticed a clump of seeds caught in the end of a cow's whisking tail and wondered enviously what finds were presenting themselves to the laborers picking wool in nearby factories. "I do not see," he writes, "but the seeds which are ripened in New England may plant themselves in Pennsylvania. At any rate, I am interested in the fate or success of every such venture which the autumn sends forth." If we can recover faith in a seed—and in the other wonders that can't fit into a sound bite—we may claim our chance at understanding our own place in the world.

Barbara Kingsolver is the author of six books of nonfiction and fiction, most recently, Pigs in Heaven. *A previous novel,* Animal Dreams, *won the Edward Abbey Ecofiction Award, for literature promoting environmental awareness.*

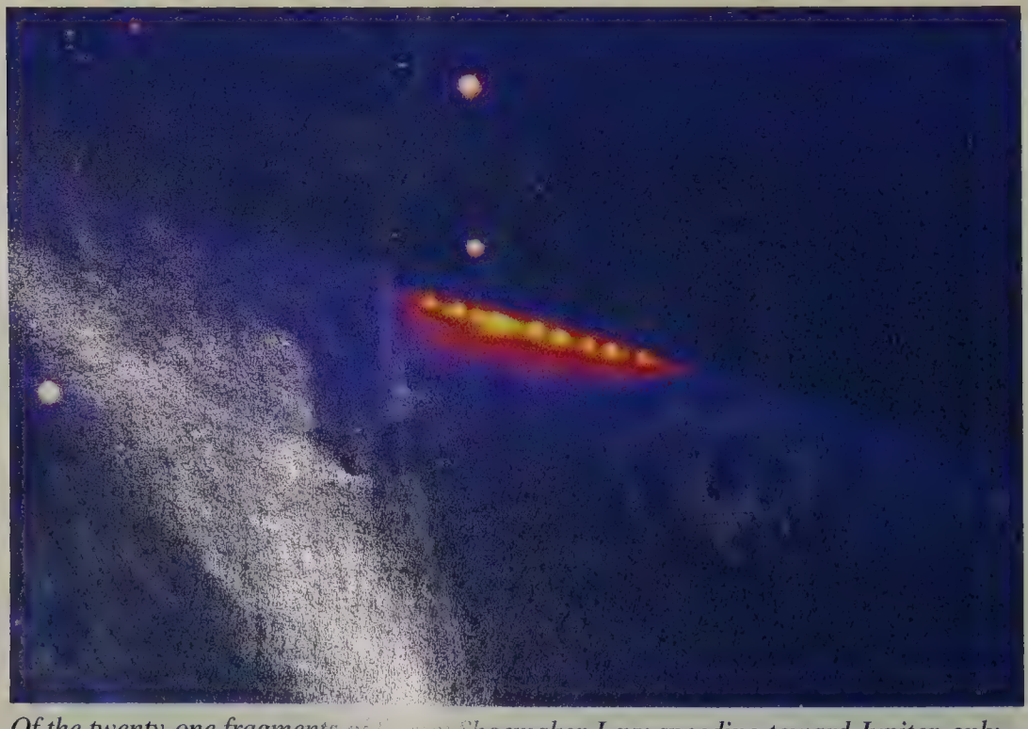


Target Jupiter

by Gail S. Cleere

Most astronomers—but surprisingly few of us regular folks—realize that our solar system, with its average-sized star and nine planets, is still in a state of flux. Far from being stable, the solar system is still sorting itself out, sweeping up the chaotic debris of comets and asteroids left over from its earliest beginnings. Recently, two astronomers—Brian Marsden, of the Harvard–Smithsonian Center for Astrophysics, and Paul Chodas, of California's Jet Propulsion Laboratory—announced the first predicted collision of such cosmic leftovers with a planet. The recently discovered Comet Shoemaker-Levy is on a beeline course for Jupiter and is expected to plow into the planet next July. At the most recent meeting of the American Astronomical Society, in Berkeley, California, NASA astronomers Chris Chyba and Kevin Zahnle described the predicted event in some detail: the resultant explosion will be equivalent to an explosion of 200 million megatons of TNT—more powerful than the simultaneous detonation of all the world's nuclear weapons.

The catastrophe that Chyba and Zahnle described may rival the collision between the earth and a comet 65 million years ago, an event which many believe killed off much of the life on our planet, including the dinosaurs. Zahnle explains that because of the comet's unusual nature, the event on Jupiter could cause the giant gaseous planet to flare up repeatedly to twenty-five times its usual brightness over the course of a few hours. Comet Shoemaker-Levy has been captured by Jupiter's tremendous gravitational field and is now revolving in an orbit around the planet. On July 8, 1992, Shoemaker-Levy passed 30,000 miles above Jupiter's cloud tops, within what astronomers call the Roche Limit: the critical distance from the center of a planet at which tidal forces are sufficient to disrupt and tear apart a satellite (or, in this case, a comet). As a result of its close approach, Shoemaker-Levy was ripped up into a train of smaller pieces—like "pearls on a string" as one astronomer described it. The best orbital computations available at press time suggest that a part or all of the cometary debris will collide with Jupiter at speeds of 40 miles per second sometime between July 23 and July 27, 1994. Donald Yeomans, an orbit specialist at the Jet Propulsion Laboratory, has calculated a probability of 64 percent that the center of the comet train will collide with Jupiter. In the case of a glancing strike, the pieces on the trailing end of the comet train might survive to escape Jupiter's gravity and go into a more typical orbit around the sun.



Of the twenty-one fragments of Comet Shoemaker-Levy speeding toward Jupiter, only the brightest can be seen in this image taken with the University of Hawaii's telescope atop Mauna Kea. Each fragment is enveloped in its own cloud of dust.

Jane Luu; University of California, Berkeley

Comet Shoemaker-Levy, once a twelve-mile-wide chunk of ice and rock, was discovered last March 24 by the comet-hunting team of Carolyn and Eugene Shoemaker, David Levy, and Philippe Bendjoya with the 18-inch telescope on Palomar Mountain. When James Scotti saw the comet with the University of Arizona's Spacewatch Telescope on March 26, he said it looked more like a "comet stream." When Jane Luu and David Jewitt imaged it with a camera mounted on the 86-inch telescope on Mauna Kea in Hawaii, they were amazed to discover seventeen separate cometary nuclei. That figure is now at twenty-one, and the largest of these—at this writing—imaged on July 1, may be six miles across.

To the immense disappointment of earthly sky watchers, this entire catastrophic event will occur on the night side of Jupiter, which faces away from us. But because Jupiter rotates on its axis once

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by R.G. Finney

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every ten hours, we should be able to see the effects of the devastation a few hours after it occurs. And the reflected light of the explosion on Jupiter's nearest satellites may be visible with small telescopes—perhaps even with binoculars.

As each piece of cometary material plunges into Jupiter's thick atmosphere, it should break into rubble and then, 100 to 200 miles down, be destroyed by intense atmospheric resistance. This destruction will cause an enormous release of energy in the upper layers of the planet. Some theorists speculate that just such an event created Jupiter's signature storm, the Great Red Spot—a whirling hurricane approximately 10,000 miles long and 5,000 miles wide—which has been seen since at least the seventeenth century.

Astronomers everywhere, including David Levy, are urging NASA to fire up aging instruments on *Voyager 2,* now sailing out of the solar system but still in a position to observe the event on Jupiter next July. Unfortunately, the *Galileo* spacecraft bound for Jupiter will not arrive there until 1995.

How often do these careening chunks of rock and ice come *our* way? More often, it turns out, than some feel comfortable about. "It's a cosmic shooting gallery out there," reported *Newsweek* magazine last year in an article entitled "The Science of Doom." During a person's lifetime, there is a one in ten thousand chance that the earth could be hit by something big enough to cause widespread annihilation—be it a comet or an asteroid. Each day twenty tons of particles no bigger than grains of sand fall to the earth. Thousands of apple-sized chunks fall, too, most of them harmlessly. Millions of jumbo-jet-liner-sized objects swarm through the solar system, and one strikes the earth every century or two. The most recent was the Tunguska event in 1908, which flattened nearly a thousand square miles of forest in Siberia. These bigger objects have created a flurry of new efforts to patrol the skies.

"It's scandalous," says Jack Hills of the Los Alamos Laboratory. "These things have been passing near Earth forever, and we have only seen a tiny fraction of them." He and his colleague Peter Leonard have proposed a low-cost detection system—clusters of small telescopes outfitted with solid-state detectors—that would spot small asteroids as they near the earth and would provide nightly coverage of the entire sky. Each telescope would scan a section of sky for a few minutes, transmit the digital image to a central control center for analysis, and move on to a new patch of sky. A computer would compare the short-exposure pictures to an image of the sky stored in memory, looking for new points of light.

Meanwhile, Tom Gehrels runs the Spacewatch telescope atop Kitt Peak in Arizona. Using a relatively small (36-inch) telescope, he searches for asteroids and comets approaching the earth by letting the telescope scan the sky several times, using the natural rotation of the earth. Objects that have moved between scans are suspect and are closely scrutinized. On May 20 of this year, just before 5:00 P.M., EDT, a boulder sixteen to thirty-six feet across (about the size of a two-car garage) passed within 90,000 miles of the earth. Had this tiny asteroid (designated 1193 KA_2) come only eighty-one minutes earlier it might well have collided with the earth, releasing enough energy to demolish a large city.

NASA, too, has weighed in on the issue. A panel there called for the creation of the Spaceguard Survey, an early-warning system made up of six large telescopes that together could spot nearly all the asteroids larger than a half mile in diameter headed our way. But some astronomers say that there's no practical way to get an early warning about many comets and asteroids bound for the earth until they're literally upon us, and then it would be much too late to do anything, even if we could. At a conference last year at Los Alamos, most scientists generally agreed that a nuclear explosion is the only way to deflect an incoming chunk of rock and ice. Luckily, Jupiter is the target this time!

The Planets in October

Mercury moves south in the sky this month, well below the imaginary line across our sky called the ecliptic (the earth's equator extended into space). This is an unfavorable position for northern observers because even though the planet reaches its greatest angular distance east of the sun on October 14, tiny Mercury remains too near the western horizon to be easily seen.

Venus remains a brilliant morning object in October's eastern skies and is high in the sky just before sunrise. Watch the thin crescent moon slide past Venus and well into the south on the mornings of the 13th and 14th as it passes just below the planet. Over the next couple of months, the *Magellan* spacecraft orbiting Venus will repeatedly dip into the tenuous outer reaches of the planet's atmosphere. Such a maneuver is called aerobraking because it uses the atmosphere to slow the probe and lower its altitude. It's risky and has never been attempted, but if successful, it should prolong the satellite's life span. Should *Magellan* fall too far down in the intense heat of the Venusian atmosphere, it could fry in a matter of minutes.

Mars is lost in the solar glare this month and cannot be seen. Slowly, it moves behind the sun, where it will remain for the rest of the year.

Jupiter also moves toward the other side of the sun, reaching conjunction on the 18th. By the end of the month, the giant planet emerges on the sun's western side, but it remains too close to the sun to be seen.

Saturn is well up in the southeast as the sun sets and remains with us until after midnight. Among the faint stars of Capricornus, Saturn is just a degree or so away from the third-magnitude star Deneb Algiedi. Look high above Saturn for the Summer Triangle, made up of the three bright stars Deneb, Altair, and Vega. A waxing gibbous moon will slowly approach Saturn from the west during the nights of the 23d and 24th.

Uranus and **Neptune** cling to the Milky Way's eastern edge in the constellation Sagittarius.

Pluto is buried among the faint stars in northern Libra, near the western horizon as the sun sets.

The **Moon** reaches last quarter on the 8th at 3:35 P.M., EDT; is new on the 15th at 7:36 A.M., EDT; reaches first quarter at 4:52 A.M., EDT, on the 22d; and is full on the 30th at 8:38 A.M., EDT.

The Orionid meteor shower (so called because these "shooting stars" appear to radiate from the vicinity of the constellation Orion) reaches its peak during the early morning hours of the 22d. Skywatchers with a clear, dark sky might count as many as twenty-five of these streaks of light per hour. Look overhead and toward the southeast between 2:00 and 5:00 A.M.

Time to "fall back." Daylight-saving time will end on Sunday morning, October 31 (Halloween). At 2:00 A.M. local time, all clocks are to be set back one hour. This applies everywhere except Hawaii, Arizona, and parts of Indiana where daylight time is not observed.

Gail S. Cleere lives in Washington, D.C., and writes on popular astronomy.

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A red colobus mother holds her 2½-month-old infant. Like other females of this species, she left her natal troop in order to fulfill her adult role.

The Kindness of Strangers

In a West African forest, three monkey species make good neighbors

Text and photographs by E. D. Starin

Just as the sun begins to filter through the dewy leaves of the forest canopy, a young green monkey scampers along a branch in pursuit of an older playmate. The adults of their troop are still not awake, but their tails provide a jungle gym for the youngsters. On a palm frond, a group of sleeping mothers huddle with their infants, all born during the same week. Each infant hangs on to its mother's nipples—often both nipples at the same time. Gradually the green monkeys' oil palm sleeping trees begin to come alive with the sounds and movements of yawning and stretching. Growing where the woodland savanna meets the riverine forest, the sleeping trees give the green monkeys easy access to both habitats.

Nearby, in the middle of the forest, in the much broader, heavier mampato trees, the thumbless, potbellied, clumsy red colobus monkeys begin to awake. The little ones—always the first to wake up—squeal, screech, and scream as they leapfrog and somersault over one another and swing from branches. They are ready to start the day. Their mothers sit in groups, resting and cleaning one another's hair and skin. An adult male—the last to wake up—presents his back to one of the females for grooming. The adults are in no rush to leave their sleeping trees and eat breakfast. And since their sleeping trees are also their feeding trees, they have only to reach out and pick some unripe fruit.



Good neighbors: A female colobus grooms a green monkey.

In the middle of the savanna, away from the humid, green riverine forest, the fleet-footed, clown-faced red patas monkeys, sensing the sun's first morning rays and the sounds of the dogs and farmers waking up on the borders of the forest, begin to forage for insects, lizards, and berries in the fallen leaf litter on the savanna floor. A mother catches a skink, eats the fleshy bits, and discards the guts. Her infant, close by her side, grabs the guts and stuffs them in its mouth before any of its playmates can find them.

The Abuko Nature Reserve in the Gambia, West Africa, consists of shady riverine forest and raffia-palm swamp, airy woodland and savanna, sunny clearings where marshes form in wet weather, and lily-pad-covered pools inhabited by crocodiles. Although Abuko is small (250 acres), its many different habitats support a varied wildlife population, including these three very different monkey species. There are about 110 to 180 green monkeys (*Cercopithecus sabaeus*), making up four to six troops; 130 red colobus monkeys (*Procolobus badius*) in five troops; and two troops totaling 40 patas monkeys (*Erythrocebus patas*). Occasionally, a young male Campbell's monkey (*Cercopithecus campbelli*) will wander alone into the reserve, spend a few days, and wander out again. Where such migratory males come from is unknown: few troops of this species are left in the Gambia; the nearest is ten miles away.

Living in comparative peace, members of the three resident species continually meet up and part again. The adults groom one another, the youngsters play together, and all of them listen to and understand one another's alarm calls. When the odd scuffle breaks out, however, the largest of the three species, the colobus, is the one that bullies the others.

The three kinds of monkeys range differently over the reserve. The green monkeys use all levels in all zones, digging holes in the sandy savanna for roots and tubers; sleeping, feeding, and resting high in the riverine canopy; even swimming in mud puddles or dragging weeds and herbs out of the crocodile pools. Fruits, seeds, leaves, bark, pith, tender grass shoots, roots, red ants, flying termites, and mushrooms all play a part in their eclectic diet.

The elusive patas monkeys are the daredevils and vanishing artists of Abuko. They raid crops from nearby fields, selecting ripe mangoes, peanuts, cereals, and vegetables and then running swiftly back to the fenced reserve. With dogs and irate farmers in hot pursuit, they climb over the fence, clutching their "stolen" goods.

The red colobus spend most of their time in the riverine forest, although they will venture out into the savanna, swamps, and clearings to feed, rest, and play. The largest component of their diet is fruit, with various other items thrown in—flowers, soil from termite mounds and runways, galls, and aerial roots from massive



The red patas enjoying a mango, below, may have stolen it from a farmer's crop. Right: A patas (left) plays with a green monkey.





fig trees. In a pinch, they also consume large leaf buds and young leaves, and so have acquired a reputation as leaf eaters. Compared with the scrambling and scurrying green monkeys and the courageous patas, the red colobus appear to lead a fairly dull, lethargic life style, spending a lot of time just hanging out in the trees within the safe confines of the reserve.

The three species rarely compete for vital resources; when they do, it is usually indirectly. For example, red colobus relish unripe swamp-date seeds. They can enter a date tree grove and wipe out the sweet, but unripe, crop. By the time the green monkeys want to feed on the dates, nothing is left. The same is true for mangoes. The colobus like mango flowers and unripe fruit. The green monkeys are left with few ripe mangoes at the end.

In some ways, the different species even increase the supply of one another's favored food sources. When the red patas raid crops for example, they bring seeds and fruits of domesticated plants back into the reserve. Most likely this is why mango, tamarind, and cashew trees now grow throughout the reserve, providing the green monkeys and red colobus with many hours of safe feeding. During the heat of the day, the red colobus rest, play, and leap through the middle story, sometimes dropping sweet mendico and fig fruits. The green monkeys sitting below on the cool, sandy floor often reach out and avail themselves of these food parcels without expending any time or energy.

One species sometimes assists another in other ways. The green monkeys appear to provide the best local alarm system. They have distinct calls that warn of different types of predators and incite their monkey companions to take appropriate escape action. When a green monkey sees a snake, such as a python, it gives a characteristic chatter and looks down at the



ground. Not only other green monkeys but also the red colobus will look to the ground searching out the danger. In response to a large bird or even low-flying airplanes or sudden bursts of falling leaves, green monkeys give another type of call. This causes both green monkeys and the red colobus to look up in the air. (No predatory birds pose a threat in the reserve, however.)

Probably the most interesting interaction of the species is the temporary joining of adolescent female and male colobus with green monkey or patas troops, for periods of a few hours to more than two years. Red colobus monkeys are one of the few primate species in which both females and males leave their natal troop upon reaching adolescence. A young female leaves voluntarily: her instincts appear to be to mate and raise young in another troop. A young male, however, is forced into exile—he is bullied, mostly by older males, and expelled. Usually he lives in

Secure in the middle of a troop of green monkeys, below, a solitary colobus can explore its natural and social surroundings. Right: The colobus diet includes young leaves.



exile, returning only when a "vacancy" occurs in his natal troop. More rarely, he may join an alien troop.

When they do leave the security of their natal troop, young colobus monkeys often spend time with green monkeys (probably because the two species have similar preferences in foods and habitats) and less commonly with patas monkeys. Being in a group, even of a different species, has its advantages, at least when both species are subject to similar predators and recognize each other's alarm calls. As part of a group, with its many eyes and ears, the individual does not have to be so vigilant and can dedicate more time and energy to feeding or to locating a troop in which to mate and raise young.

Green monkeys and patas monkeys provide handy "escort services" for young colobus on the move or in exile. Young female colobus, for example, sometimes disappear from their natal troop, often in pairs or groups, for a couple of hours or a night, and spend time with the local green monkey troop, playing, grooming, resting, and feeding. These wanderings always occur just before they switch troops for good. The green monkeys have a much larger home range and cover more ground each day than the colobus. By spending a few hours with them, the young females can explore farther than if they spent all their time with their own species.

One young colobus female proved to be a real renegade. She and the rest of her natal troop spent one entire morning chasing and threatening members of a patas troop. When the patas troop finally moved off in the direction of another colobus troop, however, she switched sides, joined the patas, and ran with them all the way to the other colobus troop. Then she deserted her patas escorts and spent the rest of the day and night with the new colobus troop.

In another case, a young female left her natal troop, joined a patas troop as it foraged through her home range, and left it when it merged with a neighboring colobus troop. In both instances, the young female colobus traveled right in the middle of the patas troop.

One advantage of this behavior, I believe, is that it enables young red colobus to sneak up on, and check out, troops of their own species, giving them a good opportunity to decide which one to join. Young males in particular are apt to get an extremely hostile reception when they approach a new colobus troop. I recorded two young males that were mauled to death by adult females when they tried to join alien troops. A green monkey or patas troop may help conceal the vulnerable males, perhaps even camouflaging their odors and the distinctive sounds of their movement in the foliage (even I can hear the difference between an agile green monkey and a clumsily moving colobus or detect the barnyardlike odor left by a colobus).

One young male colobus spent more than two years as a full-fledged member of a green monkey troop, feeding, resting, playing, and sleeping with them day after day. Only when he was surrounded by these companions was he able to spy successfully on a colobus troop without being seen. On the rare occasion when he was on his own, he was immediately spotted and chased off by screaming colobus females.

Young colobus females and males are looking for different things in a new troop. Females gravitate to other females that have moved from their natal troop, individuals they grew up with and with whom they have already spent years playing and grooming. Very often, two or more females make a transfer together. This strategy provides them with familiar, trusted allies that can help them combat the mild threats they experience when they first join a new troop and, when they become mothers, fight off potentially infanticidal males. Males, on the other hand, are waiting in exile for the opportunity to rejoin their natal troop. If no vacancies arise, they may attempt to join an alien troop—a risky alternative.

As evening falls on the Abuko Nature Reserve and the sun begins to slip behind the horizon, a young male colobus sits in a group of green monkeys on the savanna. He feeds on a sweet-smelling, foul-tasting tamba fruit. Three young colobus females settle into a new troop. They have left their mothers, their sleeping trees, their younger brothers and sisters, and their food sources for a new home. In the dark, the green monkeys huddle in their oil palm trees. The colobus settle down in their mampatos, and the patas sleep on the reserve edge, ready to raid the fields the next morning. □





A pair of common ravens roost in a conifer.
James Brandenburg; Minden Pictures

A Birdbrain Nevermore

When put to the test, ravens display insight

by Bernd Heinrich

The ancient Vikings revered ravens as messengers of the gods, and Native Americans of the Pacific Northwest gave the raven the role of benefactor in their mythology. Even today, in Ireland, a wise person is said to have "raven's knowledge." How has the raven acquired this reputation? Is the bird truly intelligent? Just what do we mean by animal intelligence, and how can we measure it or distinguish it from instinct or from learned behavior? My many years of experience with ravens, both wild and tame, have given me great respect for these birds and led me to devise ways in which to test behaviors that have struck many generations of observers as downright clever.

The underlying assumption of intelligent behavior is not performance but consciousness, something nearly impossible to test directly. Nevertheless, animal consciousness has increasingly become an object of scientific inquiry. Donald R. Griffin, a professor of zoology formerly at Rockefeller University in New York, defined consciousness in terms of intentions. "An intention involves mental images of future events in which the intender pictures himself as a participant and makes a choice as to which image he will try to bring to reality.... The presence of mental images, and their use by an animal to regulate its behavior, provide a pragmatic, working definition of consciousness."

Few people would quibble with the idea that an animal that can visualize a problem and its solution demonstrates intelligence, or a capacity for insight. Insight is not a function of complexity of response or of seeming purpose, or "goal-directedness," in behavior. If it were, then insects might be considered some of the most intelligent animals on earth. But most of the complex behaviors of insects are encoded at birth on the animals' nervous system, part of their evolutionary inheritance, their "instinct." (At the other extreme, humans have intelligence, yet an impartial observer might point to all sorts of irrational human behavior that could demonstrate lack of insight.)

One of the first scientists to attempt to show that animals other than humans have insight was Wolfgang Köhler, who in 1917 reported on some then extraordinary observations of chimpanzees. Köhler had placed a banana out of reach of six hungry chimps in a room that contained a wooden crate. Most of the chimps eagerly jumped up, trying to grab the banana. One of them, however, held back, then pushed the crate under the banana, climbed on top, and grasped the fruit. Was this a lucky coincidence, instinct, learning, or a demonstration of insight? In 1984, researchers at Harvard University gave pigeons a variation of the banana test. Like the chimpanzees, the birds could push a perch to reach food, but they first had to be taught to move the perch and also to hop onto it. No pigeon spontaneously "got the idea" without prior learning.

Insight in birds had been posited at least fifty years earlier by a number of researchers who described caged birds such as finches and tits pulling on strings to draw food toward them. Although some researchers thought that this behavior showed insight, others pointed out that it could have developed gradually by learning instead. The few critical studies of this behavior showed slow learning but no sudden leap of performance, as might be supposed if the bird had a sudden mental flash of the problem and its solution.

What I'm leading up to, of course, is ravens. Many people would like to believe that such magnificent birds are intelligent, and I thus here state my bias. I love ravens and their relatives the crows. But my appreciation of them is not altered one whit whether their behavior is guided by insight, by intricate learning, by evolutionary programming, or by some combination of all of these. Whatever its origin, their behavior is remarkable. That said, I will also venture to comment that published proof of the raven's intelligence is nonexistent. The raven's braininess is, so far, not a matter of fact, any more than are its fabled cunning, divining powers, mischievousness, and sense of humor, although all these were accepted as truths for centuries. What has passed for raven intelligence can conceivably be explained by other hypotheses.

I have applied this conservative approach to numerous reports of raven intelligence. A note in a recent ornithological journal, for example, describes a pair of ravens throwing rocks at two researchers who had climbed to the ravens' nest on a desert cliff. The distraught raven parents remained directly above the interlopers, dislodging stones that dropped onto them. So far so good. But was this a *calculated* response to a threat? It may have been, but I believe a simpler explanation exists. Whenever I have climbed up to ravens' nests in Maine and Vermont, one or both of the parents usually stayed and displayed their anger by landing close to me, all the while violently hacking at anything near them. Since these were tree nests, the birds, unlike the cliffside [illegible], had a number of perches available to them. They perched on trees near but not directly above me, and the twigs they bore [illegible] the ground instead of on me. [illegible]



tion of the rock-throwing ravens could have been basically the same as that of the frantic tree-nesting ravens. Context could make the raven behavior on the cliff appear to be intelligent and that in the forest irrational.

A second published report describes a raven jumping up and down on a lawn where voles had tunneled beneath the snow. The author concluded that the jumping was a deliberate attempt to flush out the voles. Yet I have observed hundreds of ravens in New England perform such jumping-jacks whenever they are nervous near potential food. They do it off snow as well as on, and next to a dead raccoon as well as next to any strange object, and sometimes merely if they are skittish.

Another class of often reported "evidence" for raven intelligence involves birds working in teams to achieve a common, rational goal. In the usual scenario, a predator (such as a wolf, fox, or eagle) holds food that a pair of ravens want. One raven will perhaps sneak up behind the feeding predator and bite it on the tail, and when the predator turns around to face its assailant, the second raven rushes in to grab the food. This can indeed happen, and it often has been cited as an example of foresight and intelligence. But ravens (and crows) will also harass dogs and other predators in the same way when no food is in sight. My pet crow has amused me many times by its habit of biting the tail of my neighbor's dog. And my tame ravens similarly approach and nip strange and potentially threatening objects or animals. If several ravens discover an eagle eating a fish, they will loiter nearby, waiting for an opening. One of the birds might tweak the predator's tail for any of a number of reasons. Another bird then seizes the opportunity to grab a meal. No conscious foresight needs to be presumed to account for the superb cooperation. Insight is certainly not excluded, but it is not demonstrated in a scientific sense.

Some behaviors, however, defy easy explanations. When feeding on suet, ravens, crows, blue jays, woodpeckers, chickadees, and nuthatches usually hack or tear off bite-sized portions in a feed-as-you-peck strategy. Near my home in Vermont, a pair of ravens often came to feed at suet, but remained nervous in the presence of humans and tried to minimize the



Avid scavengers, ravens gather at carcasses. At left, an aggressive raven distracts a wolf at the remains of a bighorn sheep. The birds often fly at and nip predators and in the process gain access to a windfall of meat. With the wolf in abeyance, a flock, below, divides the spoils.

Both photographs by Michael H. Francis



amount of time spent near the house. One day I inadvertently flushed one of the members of the pair from a large, frozen chunk of suet. Instead of pecking at the lump and extricating bits of the fat, this bird had chiseled a groove three inches long and more than a half inch wide. Scraps of fat were adhering to the groove, so that if the bird's objective had been to eat, it could have done so easily, then and there. Yet by gouging out a sizable portion, the raven (had I not flushed it) could have removed and carried off a much larger piece of suet than it could have eaten piecemeal in the same amount of time. It appeared to have sacrificed immediate gratification, and expended a considerable effort at the time, for a greater reward later. Its suet carving appears to be a vivid inscription of a raven's mental plan.

I devised an experiment to test for the role that consciousness might play in behavior. I needed to present the animals with a simple task that required many separate steps. In addition, no reward could be given for partial completion of a task, so that learning one step at a time would be eliminated. (Such an approach contrasts strongly with the usual learning paradigm, in which a researcher or trainer conditions an animal to complete a task by gradually shaping its behavior through rewards.)

My subjects were my tame American crows and common ravens, which I had kept for more than seven years. The first birds I investigated in detail were housed in an outdoor aviary abutting a picture window of my house. In addition to a long, horizontal pole for perching, the cage contained small trees. The ground was covered with leaves in fall, snow in winter, and greenery in summer. Thus, it was not a cramped, confining space with a single perch, where bored animals are apt to pull or yank on anything. In this enclosure, the birds had a choice of many behaviors.

I gave these hand-reared birds a simple mechanical problem that involved pulling a string to manipulate a piece of meat from a distance. The birds had never seen or used string. I suspended the meat from their horizontal perch by a string some twenty-five inches long. H[illegible]s can easily visualize a solution: to obtain the meat a bird would have to land on the perch above it, reach down with [illegible] loop of string, step onto the [illegible]

To reach a chunk of meat suspended from a twenty-five-inch string, a tame raven, wing-marked for identification, reaches down, tugs the string, anchors it with its foot, and then repeats the process several times in a precise sequence.

Photographs by Bernd Heinrich





chor it, release the bill, reach down again to pull up another loop, and so on, in a repeating cycle of more than twenty steps until the meat was raised to the perch. All of the steps have to be executed in a precise sequence. Because each of the mechanical steps is extraordinarily simple, the task itself is simple—if a creature has insight. The problem is more complicated for a bird that has no concept of string or what it can do. I doubted that a bird could solve the problem without a lengthy, tedious learning process.

When I left the dangling meat, both of my crows (which I had not fed in a day so they would be suitably hungry) immediately showed a[illegible]erest in the food. They examined the chunk of meat, flew at it, then pecked and pulled at the string where it was attached to the perch. But being inaccessible, the meat was ignored within fifteen minutes. After the first day, I fed the crows without satiating them and continued to watch at the picture window to be absolutely sure I didn't miss anything. I finally stopped watching but left the meat hanging, changing it on subsequent days and offering all sorts of delectables on strings. Thirty days later the bait was still hanging. The crows had failed to figure out how to gain access to the meat, and although I suspect I could have taught them, I did not. I was interested in what they "knew," not in what they might learn.

The crows were interested in the meat because when I lifted it up and placed it on the perch, they invariably grabbed it and tried to fly off with it. Each time they did so, the meat was yanked out of their bills before they had flown two feet. They did not comprehend that it was attached to something. However, after five and nine such trials, respectively, the two birds refused to fly off, and instead ate the meat in place on top of the perch. If they were induced to take flight, they then always dropped the meat first. This showed that they could quickly learn to avoid having the food wrenched away, but they still did not draw the conclusion that they could pull the meat up by using the string. These results were precisely what I had, with my cautious biases, expected.

Then, in the same aviary, I gave the





same test to five tame ravens. The ravens also immediately closely examined the dangling meat, but I had the impression that they retained an interest in it even though they were not instantly able to reach it. Unlike the crows, they kept glancing at it, as though studying the situation. After about six hours, one raven landed again on the perch, reached down to pull up a loop of string, stepped on it, reached down again, and proceeded to complete the whole sequence of pull-step-release-pull to reach the meat. I was amazed; I knew that the bird had not "practiced" at all, because I had been watching the ravens without pause for six hours. This bird had performed the sequence flawlessly on its very first attempt. I now chased the bird away from the perch before it had a chance to feed. When it took wing, it spontaneously dropped the meat. Within seconds it was back, eagerly pulling the meat up with the string. Now it could not be kept away. Every time I chased it, it dropped the meat before lifting off. The behavior had not been a fluke. The bird "knew" how to get the meat. Furthermore, it knew enough to drop the meat without any trials or practice.

Three more of the five tame ravens (all marked with conspicuous numbered tags on the wings) followed suit, showing sudden proficiency in the string-pulling task. While these birds could have learned from the first raven, I doubt that this was the case. Several days had passed since the first raven's performance, and two of the other ravens used a "side-step" rather than a direct "pull-up" technique to hold the string. Learning through observation would not preclude insight on the part of these birds, yet the critical maneuver—pressing and holding the string to the perch—would have been difficult for them to see at all. Like the first raven, none of these ever attempted to fly off with meat they had pulled up. These results are very simple to explain if the ravens had a mental picture of what they were doing. If they did not, then the outcome is puzzling. I wanted to test the simplest hypothesis, that they "knew," even further. To do that, I first needed to try to trick them.

Did the ravens now automatically asso-



With four-foot wingspans, common ravens are the largest of perching birds. They live year-round in the colder mountainous and forested regions of North America, Europe, and Asia.
James Brandenburg; Minden Pictures

ciate string with food, and would they pull up any string without examining whether or not meat was actually attached? I hung two strings, close together, from the perch. One held a piece of meat and the other a stone of equal weight. I expected both to be pulled up with nearly equal frequency. But in over one hundred trials, the ravens never once pulled up the rock. In their haste, however, the ravens often contacted the wrong string by pecking it or giving it a brief tug. These mistakes were precisely the ones I now found useful in delving into the basis of the birds' behavior. One tug was generally enough to let a raven decide whether or not to continue the entire sequence of steps, and I had the distinct impression that the ravens looked down as if to watch the meat. If they saw the meat move, they knew they had the right string. If the rock moved, they jumped back immediately to correct their mistake.

Eventually they learned to look even before they tugged, and I was able to test more specifically what they looked for. I crossed the two strings, fixing them in place with fine thread. Two of the ravens consistently first tugged on the wrong string (but still only pulled up the right one). Their consistency of choice amazed me. They made the same mistake twenty trials in a row, as if not only unable to learn but also unable to try the other string. Their behavior was not random. They were dead wrong, but they were apparently convinced they were right. The other two birds made no mistakes on the crossed-string experiment right from the beginning. Thus, the same overt behavior was based on two internal rules. One said "Pull string over food." The other said "Pull string connected to food."

The ravens, so far, had experience only with sisal twine. However, the way to access meat was not to pull on sisal twine, but to pull on whatever happened to be connecting meat to the perch. Had the ravens gotten this essential point or had they merely [illegible] association between sisal twine and [illegible]. When I presented them with a [illegible] woven string holding meat, and [illegible] attached to a stone, they pulled only the woven string, which they had never seen before. They knew the essential point without ever having learned by trial and error.

I then hung up a sheep's head on which the ravens had been feasting and near it a small piece of meat on another string. I knew that they would be unable to hoist the heavy sheep's head, much less hold the string in place with one foot or even both feet. But would the ravens know this without learning by trial and error? Was their previous success due to a series of mere mechanical steps that miraculously resulted in the appearance of food? As before, the ravens surprised me. They never even once tried to pull up the sheep's head. They acted as if they knew what they were doing.

My five sets of observations and experiments make highly plausible the idea that some ravens can form a mental image of at least one problem and its solution. None of the observations can be explained easily by shoehorning it into the notion that learning occurred in the absence of insight. While insight can follow learning (at least, most of us who teach dearly hope so), the results with ravens show that it can also precede learning.

I later gave the same test to two groups of wild-caught ravens, of fourteen and thirteen individuals, respectively, in a huge outdoor aviary in Maine. After just fourteen minutes, one bird deftly pulled up the meat. But finally, only three birds in one group and four in the other "knew" how to attain the prize. This gap in performance argues against this behavior being instinctual and also perhaps against observational learning. It does support the idea that consciousness is not innate but individualized. As reflected in the perception of problems from pulling up meat to pondering the universe, consciousness covers a great range. (The gradations of consciousness somewhat redeem the two crows and the less brainy ravens that I tested.) Ravens may not be the cunning, clairvoyant creatures of folklore, but the ability of some ravens to see and solve a problem attests to their intelligence. □



A crab spider conspicuously consumes a fly in the center of a black-eyed Susan. While it waited to ambush prey, however, it sat camouflaged on the yellow petals.
Gary Meszaros; Dembinsky Photo Assoc.



Little Murders

Leaving only fang marks, crab spiders drain their victims more thoroughly than any vampire

by Simon D. Pollard



Sitting in a field of goldenrod and Queen Anne's lace in northern Virginia, I was surrounded by thousands of insects. Warmed by the July sun to a frenzy of activity, they moved from flower to flower in a mad rush for nectar. The insects I was looking for, however, were those that had failed to leave the flowers on which they landed. They were now lying in unnatural poses among the flower petals. One was a honey bee I found suspended from the edge of a flower. Controlling this macabre puppet was a female crab spider, her fangs buried in the bee's neck. The spider's body and two pairs of long front legs perfectly matched the bright yellow of the goldenrod in which she was hidden. Only her failure to hold her victim in a more lifelike pose betrayed her presence. When I returned the following day, I found the bee's corpse on the ground, discarded but apparently intact. I had to examine the body closely to tell that its tissues and fluids had been removed through tiny fang holes.

In New Zealand, I had studied how these spiders feed, but the crab spiders—both males and females—that I observed in Virginia offered a number of surprises. The species *Misumenoides formosipes* is common throughout much of North America, and I had chosen to study it because the females were ten times larger than any I had studied in New Zealand. The difference in size made studying their feeding mechanism a lot easier.

Like most crab spiders, *M. formosipes* sits motionless on flowers, waiting for prey to come within reach of its large front legs. The female's ability to change the color of her body and legs to match the whites and yellows of flowers makes her a formidable predator of pollinating insects and affords her some protection from becoming a victim herself. The crab spider's practice of draining the contents of its prey through a few holes was well known, but exactly how it accomplished this was a mystery. As I watched this spider feed, the question that went through my mind was, "How did you get the insides of the bee out without damaging the container?"

All spiders can ingest only liquids, pre-



Robert Noonan

With her fangs buried deep in a moth's neck, left, a female crab spider draws out her liquid meal. A well-camouflaged female M. formosipes, *below, lurks behind goldenrod flowers. Her fangs, folded under her chelicerae, are just visible.*

Simon Pollard



ticles larger than a micrometer are filtered out by hairs lining the entrance of the mouth. Thus, before a spider can consume an insect, it must liquefy the prey. It does this by bathing the insect's tissues with digestive enzymes that begin to break them down. Once the food is sufficiently fluid, the spider uses its powerful sucking stomach to draw the meal through its narrow esophagus and into its midgut, where digestion is completed.

Spiders differ in the way they gain access to the prey's tissues, however. Most crush and rupture the exoskeleton by kneading it with their chelicerae (the pair of appendages to which the fangs are attached). The exposed tissues are then bathed in digestive enzymes, dissolved, and sucked up. After the spider has dined, the body parts littering the area suggest great violence. Often the prey is in so many pieces that it is difficult to identify.

Crab spiders and cobweb spinners, such as black widows, are more refined in their feeding habits. They keep the prey's exoskeleton intact while sucking the contents through tiny fang holes. This would not seem remarkable if these spiders fed from many different sites in the prey's body, but in the case of the crab spider, the discarded prey is not full of holes. Usually, only two pairs of fang holes, one in the head or neck and the other in the posterior abdomen, pierce the corpse.

After I had watched female *M. formosipes* feed in the field and under a microscope in the laboratory, the details of how they caught and digested a honey bee became clear. Moments after a bee lands on a goldenrod flower, its proboscis splashes into the pond of nectar at the base of a flower and begins drawing up the liquid. The crab spider slowly embraces the bee with her long, outstretched front legs; then with a sudden lunge, she stabs her fangs into the bee's head, injecting venom directly into the brain. After a few moments, the bee stops struggling, and the spider will either feed from the head or, if the prey is large, pierce its neck to get a better grip.

By shining an extremely bright light through a spider and its prey while they were positioned under a microscope, I could see fluid, air bubbles and all, moving between the two. The spider sucks up the prey's juices for a minute or so and then mixes its own digestive fluid with the bee's tissues. Because the fangs make only two holes in the otherwise intact exoskeleton, the sucking creates a vacuum. As the spider continues to feed, it sucks for longer periods, lasting three to four minutes each. When the vacuum within the prey's body becomes too strong to suck against, the spider relaxes the muscles around its stomach, and most of the fluid it has extracted from the bee flows back into the partly emptied shell. This allows the spider to mix its digestive fluid with parts of the bee, such as the tissue in its legs, that are remote from the puncture wounds. When the spider has extracted all it can from the holes in the neck, it retains the food, withdraws its fangs, and moves to feed on the abdomen. Thus, the bee's body is more than just a source of food; it is a part of the spider's feeding mechanism, a temporary extension of its digestive system.

The feeding behavior of male *M. formosipes*, while not as gory as its mate's, was a surprise to me. Mike Beck, a student from the University of Virginia who had recently completed a dissertation on the reproductive biology of these spiders, told me that he and Gary Dodson, a visiting postdoctoral fellow, had seen males drinking nectar from the flowers of Queen Anne's lace. Except for one report of similar behavior in a jumping spider in Ghana, I had never heard of spiders consuming nectar. I spent the rest of the summer looking into this phenomenon.

Male crab spiders, weighing [illegible]



five milligrams, are tiny compared with females, which, when swollen with eggs, can weigh almost 300 milligrams. The size difference is mostly attributable to diet and life style. In Virginia, the crab spiders emerge from their egg sacs in April and mature in August. Adult females continue to feed voraciously since the number of eggs they produce is dependent on how much they weigh, but males rarely catch prey during their last three to four weeks of life. Instead, they spend their brief adult lives courting and copulating with females, relying on energy stores accumulated while they were immature. Because of their small size, however, males lose water by evaporation at almost twice the rate of females and risk fatal dehydration without a source of water.

Observing the males feeding on the tiny nectaries of Queen Anne's lace was especially difficult because the spiders are skittish and hide underneath the flowers if they detect movement. In the laboratory, I built a small device that allowed me to rotate an umbel of Queen Anne's lace gently in three dimensions while I looked at it through a microscope. If a male approached a nectary, I could rotate the flower into a position that allowed me to

James C. Godwin

Resembling part of the flower she is sitting on, a female crab spider, left, awaits her next meal with outstretched arms. A praying mantis, below, rips apart a female M. formosipes.

Simon Pollard



see what he was doing. After many frustrating hours of watching males run out of focus, I finally saw the details of what Beck and Dodson had reported.

A male approaches a flower, holds it with his front legs, leans forward, and pushes his mouth into the tiny pool of the bulbous nectary. He sucks the fluid into his body, occasionally squeezing the nectary with his chelicerae to push more fluid toward his mouth. After drinking for about a minute, he moves on to another flower.

I never saw females drink nectar. In proportion to their body weight, the reward for time spent per nectary would be extremely small compared with the energy they could get from feeding on a large insect. Males, on the other hand, are so small that in addition to the water, sugar in the nectar might provide a significant energy boost. To see what benefits the males derive from the nectar, I set up a laboratory experiment with artificial flowers, some containing water and others simulated nectar (a 30 percent sucrose solution). Given a choice, males almost always chose the sucrose over the water. Even males that had had their fill of water and had sat inactive for an hour between two artificial flowers containing water, would begin drinking again when one of the flowers was swapped for one with sucrose.

Males I observed in the field would usually drink from only a few flowers each hour. I thought this casual intake of nectar might provide additional energy to prolong their short lives. After all, if they were relying mainly on the reserves accumulated from prey caught before they matured, any additional energy intake would likely to increase longevity. In the laborato-

Scott Nielsen; Bruce Coleman, Inc.

A male M. formosipes, *below, sips from the nectaries of Queen Anne's lace. Hiding on a bull thistle blossom, right, a female crab spider awaits her next victim.*

Simon Pollard



tory, I found that males given nectar did indeed live several days longer than those given only water.

Males mature a few weeks before females and locate immature females to guard. When a guarded female matures, the male mates with her and then leaves. This strategy guarantees a virgin female, increasing the chances that a male's sperm will be used to fertilize her eggs and will not be in competition with sperm from other males. The males spend their remaining time searching for additional receptive females. If males can increase their life span by drinking nectar, they also increase their mating opportunities. Like athletes drinking glucose before a race, males may top up on nectar when they detect rival males in the vicinity.

On rare occasions, I saw males visit flowers in such a frenzied fashion, up to eighty in an hour, that I suspected they were severely dehydrated and trying to replace lost body water. This strategy is not very efficient, however, since there are only four-millionths of a gram of water in every nectary. A male drinking dew or rainwater can take in the equivalent of sixty to eighty nectaries in about five minutes. Nonetheless, if no water is available, a male could avoid dying of dehydration by slowly filling up on nectar. The one male I managed to photograph drinking nectar was dashing from flower to flower as if his life depended on it; he seemed oblivious of my lens and flash, less than an inch away. Most males would have retreated under the flower to avoid the enormous form looming above them.

To reach the nectaries, males often brush past the pollen-laden stamens that protrude like flagpoles above the flowers, and their bodies become sprinkled with pollen. When males are rejected by females or threatened by rival males or predators, they often move to another plant and consequently transfer any pollen that they are carrying. Males are therefore capable of flower pollination, a role not normally associated with spiders. Female crab spiders may also be pollinators, but through a less direct route than males. During the struggle to subdue their prey, females catching pollen-laden insects often end up with a lot of their prey's pollen on their own bodies. And like males, females also move from plant to plant if, for example, they are ejected by a rival female searching for a better feeding site or if they are trying to escape predators such as birds or praying mantises.

I once saw a female crab spider feeding in the meadow when a praying mantis landed on the same goldenrod plant. Ungainly in flight, the mantis appeared to crash land on the plant, causing flowers to sway as if they were blowing in the wind. Within a short time, however, the mantis was walking on the goldenrod flowers, terrorizing the community at its feet, like a graceful Godzilla in a Japanese horror film. When the predator detected the female crab spider, it plucked her off the flower. Holding her with one of its front legs, it pulled her apart with the other. Curiously, the only time I saw males being eaten was when they strayed into the arms of an unreceptive female that had decided to use the male's tissues rather than his sperm as a contribution to her reproductive success.

Ultimately, the feeding behavior of both male and female crab spiders can be viewed as strategies to increase production of offspring. The number of eggs a female produces is related to her mass and, therefore, to the number of insects she eats before laying her eggs in mid-September. She increases the chances her offspring will survive by guarding the eggs until her death a few weeks later. Male success is determined by the number of females he fertilizes and is influenced by his longevity and success at outcompeting rivals in conflicts over females, both of which may be enhanced by drinking nectar. Reproductive success, however, also depends on survival; a fit male or fat female that ends up in another predator's digestive system is a loser. □







A Disarming Diner

Predatory sea slugs drop in for lunch—but the host survives

Photographs by Norbert Wu

They may resemble flower blossoms, but sea anemones are invertebrate animals that feed on tiny plankton. Their living, often colorful "petals" are tentacles, each of which contains thousands of poison stingers that repel most predators and can paralyze small prey. Some species, like this tube anemone, left, photographed in Monterey Bay, California, retreat from danger into hard, shell-like cylinders. Because they are usually anchored to a fixed spot on a reef or ocean floor, sea anemones can hide, but they can't run.

The flame nudibranch, or sea slug, left (bottom), specializes in feeding on the tentacles of live tube anemones. Upon approaching an anemone, the slug rears back and exposes its radula, a sawlike organ with thirty to sixty rows of "teeth." Then it jumps into the center of the anemone and devours a few tentacles, poison stinging cells and all, right, top. As the anemone withdraws into its tube, it pulls the dining slug even farther inside, right, bottom. The nudibranch is not only immune to the anemone's poison; its digestive apparatus separates undischarged stinging cells and stores them for its own defense. Sometimes, after dining, the sea slug deposits strands of white eggs on or around its victim.

Anemones do not seem to be permanently injured by the sea slug's depredations. Regenerating new tentacles, they can live for as long as ten years after an attack. In a sense, the slugs "farm" their prey by eating only part of their victims. Both animals are found along the Pacific coast, from Alaska to northern Mexico.—*R. M.*





The Tepee with Battle Pictures

A gift made to a Kiowa chief lives on, a century and a half later

by Candace S. Greene

At the beginning of the nineteenth century, the Kiowa, lured by the horses that could be acquired from the Spaniards, moved from their homeland at the headwaters of the Yellowstone to the southern Plains. Horses changed buffalo hunting from a means of subsistence to a source of plenty and helped transport the resultant wealth. With the new way of life, a tribe needed firearms to defend its hunting territory from competing groups. Initially, the major sources of firearms, ammunition, and weapons repair were the trading posts located on the Missouri River system, far to the north and east. But in 1833–34, Charles Bent established a trading post in eastern Colorado, in territory controlled by the Cheyenne and Arapaho. For some years, the Kiowa and their Comanche allies battled the southern bands of Cheyenne and their Arapaho allies for free access to the post. Finally, in 1840, the tribes agreed to a lasting peace and alliance. Little Bluff, principal chief of the Kiowa, negotiated the peace with High Backed Wolf, a prominent Cheyenne chief.

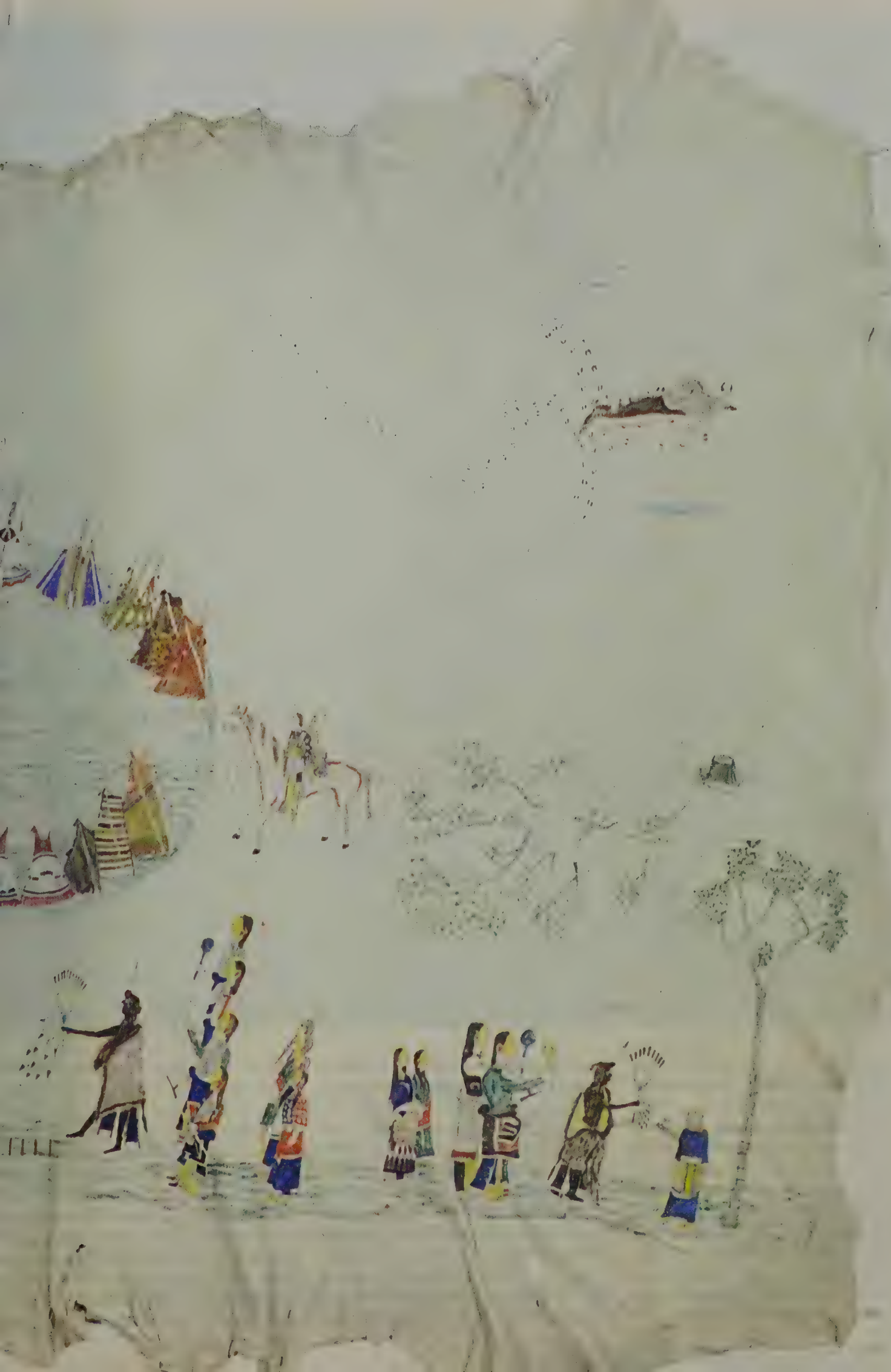
Five years later, Little Bluff and the Cheyenne chief Sleeping Bear, who had become his partner in a formal pact of friendship and mutual support, commemorated the continuing peace between the two tribes. Sleeping Bear presented his friend with a fine painted tepee. In accepting this special gift, Little Bluff presented Sleeping Bear with a number of horses, including a highly valued, black-eared racing mount.

Among the Kiowa, as among the Cheyenne, painted tepees were objects of considerable prestige. Less than 20 percent of tepees were painted; the rest were



A painting on buckskin shows the Kiowa camp surrounding the center pole erected for the Medicine Lodge. Recognizable by its stripes, the Tepee with Battle Pictures is the second one south of the camp opening. Executed at the turn of the century by Silverhorn, a grandnephew of the Kiowa chief Little Bluff, the painting was part of a series commissioned by ethnologist James Mooney to portray phases of the traditional Medicine Lodge ceremony.

National Museum of Natural History, Smithsonian Institution



Museum of the Great Plains, Lawton, Oklahoma



of plain buffalo hide. An ordinary tepee belonged to the women of the household, but individual men owned the painted ones. Most tepee designs were spiritual in origin, inspired by a man's vision, dream, or other encounter with the supernatural. Sometimes, however, a man captured a tepee from an enemy tribe or received one as a gift from an ally. Whatever its origin, a painted tepee could be passed on to other members of a family (by blood or marriage), and a design might persist for decades. At the time he received the tepee from Sleeping Bear, Little Bluff already owned a painted tepee known as the Yellow Tepee, which he had inherited from his father.

Sixteen horizontal yellow stripes boldly adorned one-half of the new tepee, sweeping around from the center back to the front, where the sides of the cover joined. They represented successful Cheyenne war expeditions. The other half was devoted to scenes of warfare, a novelty for the Kiowa, who painted battle scenes on hide robes and calendar records, but not on tepees. As a result, the Kiowa named the tepee *Do-giagya-guat,* Tepee with Battle Pictures. Because tepees stood with the doorway facing east to greet the rising sun (and the back to the west, braced against the prevailing winds), the half with the battle pictures was known as the north side and that with the stripes as the south side.

Little Bluff soon added his own embellishments to the tepee. Between the yellow stripes he inserted fifteen black stripes, for successful war parties he had led. Down the back on the north side, he added



Chief Little Bluff, below, painted by George Catlin in 1834, received the Tepee with Battle Pictures in 1845. The rights to its design subsequently remained in his family. With actors Ester LaBarr and White Parker, left, a version of the tepee appeared in the 1917 silent film Daughter of the Dawn.

National Museum of American Art, Smithsonian Institution; Gift of Mrs. Joseph Harrison, Jr.



twenty tomahawks. These represented the coups, or deeds of war, that the prominent warrior Heart Eater had achieved with that weapon in combat with Pawnee enemies. Above the front doorway, a row of eight feathered lances symbolized the coups Sitting on a Tree had compiled with that weapon. A picture of a warrior encircled by enemies decorated the top on the north side. The story of this deed was contributed by Feathered Head Pendant, a Comanche ally of the Kiowa who, surrounded by Mexican troops in about 1830, had defended himself all day behind a breastwork hastily scooped out of the sand, eventually escaping after killing one of the soldiers.

Buffalo-hide tepees rarely lasted more than one year in regular use. They became smoke- and weather-stained and rotted around the bottom where they were staked to the ground. Poor people might get by with cutting off the bottom and making do for another year with a smaller tepee, but a prestigious dwelling demanded regular renewal. A tepee required about twelve freshly tanned buffalo hides and twenty-two poles. The Tepee with Battle Pictures was a little larger than most, requiring perhaps two more hides. Men killed the buffalo to secure new hides, while women tanned the hides and cut and sewed them to make the tepee cover. The men then did the painting.

Summer was the ideal time for tepee renewal because the hair on hides secured in this season was more easily removed. Also in summer, the Kiowa left their dispersed hunting camps and came together in larger groups, culminating in the great tribal gathering at which the Medicine Lodge ceremony was held. This assembly allowed for wide participation in the painting of the cover and provided an appreciative audience for display of the beautiful new tepee.

Little Bluff would invite as many as

Museum of the Great Plains, Lawton, Oklahoma



A scale model of the tepee cover, below, was commissioned for exhibition by James Mooney. Hunting Horse, right, played a supporting role in Daughter of the Dawn. *The tepee in the film was painted by Charley Buffalo, a grandnephew of Chief Little Bluff.*

National Museum of Natural History, Smithsonian Institution



twenty to thirty men to participate in the renewal of the Tepee with Battle Pictures. They would discuss what events were worthy of depiction and would agree on two or three dozen. While the black and yellow stripes and the rows of tomahawks and lances were permanent features, other scenes might change. The space at the top was reserved for a "circle picture," a valiant stand in which a warrior surrounded by enemies eventually made his escape. In time, the Comanche picture gave way to one depicting the famous Kiowa warrior Big Bow with his wife Black Bear (who often accompanied him on war expeditions), surrounded by Mexican troops. Later the honor went to Yellow Wolf, encircled by Osage enemies.

A man's deeds were not included without his permission, since he owned the story of his accomplishments and their representation. But few would decline such an honor. The actual painting of the scene might be done by the hero of the event, by the owner of the tepee, or by any competent artist working under direction.

Intangible property played a significant role in Kiowa life. In addition to tales of military exploits, individuals owned the rights to their creative products. A man would not sing a song another had composed without permission. The same principle applied to a woman's beadwork designs. While a woman might present a pair of beaded moccasins to another person as a gift, this did not give the recipient the right to copy the design. Formal names, as distinct from common nicknames, were among the most valued items of property. Distinguished names usually circulated within a family, their bestowal being a mark of honor.

Although Plains Indians were not the only tribes that recognized nonmaterial, high-status goods, such weightless baggage was ideally suited to their nomadic life style. If property was destroyed by fire, as the Tepee with Battle Pictures was in 1872, or in the course of warfare, the loss was a temporary one. The rights to the design, the real source of the tepee's value, endured. Even if a tepee was not made for a period of time, the rights were undiminished and could be reactivated. The transfer of such important property was normally marked by a great feast and the presentation of return gifts. The guests at the feast served as witnesses to the exchange and the value placed upon the tepee or other property. In this way, the origin, ownership, and transfer of a tepee design were recorded in memories and community oral traditions.

With the rights to a tepee came the right to a designated camping position when all the tribe gathered for the Medicine Lodge ceremony. At that time, the tribe set up the tepees in a great circle opening to the east, its form echoing that of the individual tepees, whose doors faced east. Little Bluff's two tepees held the two most prestigious positions within the circle, immediately south of the entrance. His Yellow Tepee stood in first place and the Tepee with Battle Pictures next to it.

In 1864, two years before his death, Little Bluff transferred the rights to the Tepee with Battle Pictures, along with his own illustrious name, to his sister's son Gathering Feathers. In Kiowa reckoning, such a nephew could be considered as close a descendant as a son, and the relationship was often more affectionate in nature. For some years, the new Little Bluff (we might call him Little Bluff II) continued to renew



A drawing from the 1870s shows the tepee when it belonged to Little Bluff II. A warrior society sash hangs at left, while three shields are displayed at right.
School of American Research; Santa Fe, NM; SAR 1990•9•3



the tepee regularly. With the death of his uncle, however, the tribe lost the leadership of a single chief whose authority all respected. The decade following Little Bluff's death was one of sporadic but debilitating warfare, as U. S. troops drove the Kiowa onto ever smaller reservations (assigned to them by treaties that the Indians poorly understood or to which only a portion of the tribe agreed). In 1875, Little Bluff II's band—among the last to surrender—was confined to a reservation in western Indian Territory, now Oklahoma.

With their hunting territory restricted and the buffalo exterminated, the Kiowa began to make tepee covers of canvas, which proved to be more durable, if not more beautiful, than buffalo hide. The canvas, as well as food and other goods on which the Kiowa came to depend, was issued by the Bureau of Indian Affairs and distributed by its agency at Anadarko. Although such goods were annuities guaranteed by treaties or payments for land cessions, they were not doled out with great regularity. The wealth that had supported feasts and gatherings at which painted tepees and other symbols of status were proudly displayed became a thing of the past. Painted tepees began to fall into disuse, and even plain canvas tepees gave way to Army-issue tents and, in rare cases, lumber houses.

In his later years, Little Bluff II gave his prestigious name to a cousin, a son of Little Bluff. From then on he was known as Shoulder Blade, a nickname reflecting the stooped posture of old age. He also sought on several occasions to bestow the rights to the Tepee with Battle Pictures on various descendants. None, however, could finalize the transfer with an appropriate reciprocal gift until 1881, when one of his sons, White Buffalo, was able to make a suitable return. Shoulder Blade continued to live in the tepee until his death in the winter of 1891–92. Made of canvas, it was the last painted tepee still in use among the Kiowa, although it had not been renewed for a number of years and was in poor condition, the images barely discernible.

When James Mooney, an ethnologist with the Smithsonian's Bureau of American Ethnology, began his studies among the Kiowa in 1891, he was particularly intrigued by the designs painted on tepees and shields. While few of these objects remained, Kiowa still held extensive knowledge about them. Mooney involved a broad a spectrum of the community in his research, while respecting local custom regarding the ownership of knowledge. He always sought to interview the person who held the rights to a design or at least a member of the family for whom the design was traditional. In addition to learning the origin and significance of the designs, Mooney employed Kiowa artists to make a drawing of each one, based on its owner's description.

Much of the financial support for Mooney's early work among the Kiowa came from funding for major exhibitions, and he was always seeking materials suit-

A tepee inspired by the Tepee with Battle Pictures, right, has been adopted by the Black Leggings Warrior Society, a Kiowa veterans organization. Its design now includes, below, the names of the eight Kiowa who died serving in the U. S. armed forces.

Both photographs by Bill Meadows





able for display. For the World Columbian Exposition, held in Chicago in 1893, he arranged for the creation of scale models of items, such as shields and tepees, that were no longer in use. For the 1904 Louisiana Purchase Exposition in Saint Louis, Mooney was determined to reproduce the entire Kiowa camp circle as it would have appeared at the Medicine Lodge ceremony in the year 1867, each tepee to stand about two feet tall. He imported buckskins and paints from Chicago and hired a number of workers to cut and sew the covers and to whittle tepee poles and pegs to stake the covers down. He again involved the families of the owners, some of whom chose to paint their own designs while others supervised the work of a skilled artist.

Mooney was not able to produce the number of tepees he had wished, and the facilities at the exhibition must have been a great disappointment. Instead of being arranged in a forty-foot circle, as he had envisioned, the tepees were spread flat against the backs of conventional glass cases. But before they were shipped east, the tepee models were set up as intended, in a circle with its opening to the east, on the Kiowa Reservation. In the center stood the brushy arbor of a model Medicine Lodge, its floor strewn with sweet-smelling sage.

One of the models that Mooney commissioned during these years was the Tepee with Battle Pictures. The model was painted by High Forehead, twin brother of White Buffalo, the son who had received the tepee in 1881. High Forehead, most commonly called Charley Buffalo, was a recognized artist. He painted the distinctive black and yellow stripes on the south side of the model and the rows of tomahawks and feathered lances on the north side. But only seven battle scenes fit onto the small cover, including one at the top of the tepee of a single warrior encircled by U. S. soldiers. Mooney noted that the battle scenes were all imaginary, for "the artist has no correct knowledge of the historical incidents recorded upon the actual



tepee." More likely, Charley Buffalo—who lived in the tepee as a child and must have witnessed its renewal on more than one occasion—used imaginary events because he knew that actual deeds should not be represented without obtaining their owners' permission.

In about 1916, Charley Buffalo painted the Tepee with Battle Pictures again, this time full size. More than a hundred people gathered to watch. Charley Buffalo invited eminent old warriors to record their deeds on the new canvas cover, in addition to the classic stripes, tomahawks, and lances. While no record exists that the rights to the tepee had been formally transferred to Charley Buffalo, perhaps by this time the tepee was regarded as a family possession rather than a purely personal one.

While many traditional gatherings had been abandoned, the twentieth century offered new opportunities for display of this prestigious tepee. A photograph of the renewed tepee appears in various publications as an elegant illustration of Kiowa tepee life. Elaborately costumed in a painted buckskin dress and holding a heavily beaded cradleboard, Charley Buffalo's wife, Mary, poses astride a horse behind the tepee. Another photograph taken on the same occasion shows a front view of the tepee. Amid other indications that the tepee stands in a fairground [illegible]



The Black Leggings Tepee honors veterans with reproductions of their service patches instead of battle pictures.
Delores Twohatchet

leans against the door, announcing "Admission—5¢." The tepee also appeared in several scenes of the 1917 silent film *Daughter of the Dawn.*

Following this grand renewal, the Tepee with Battle Pictures again ceased to be made, although it continued to hold an important place in Kiowa oral tradition. By the 1960s, tepees had begun to reappear at powwows and other Indian gatherings, as well as at tourist events. Most were plain, but a soaring tepee set amid the jumble of canvas and rip-stop nylon tents and pickup campers brought significant family prestige. The Tepee with Battle Pictures itself made a brief reappearance in 1961. This incarnation, based on an illustration of the model in one of Mooney's books, was painted by a great-grandson of Little Bluff, Roland Whitehorse (unfortunately, it was soon ruined when fats oozing from the poorly tanned hides caught fire and the tepee had to be doused with water).

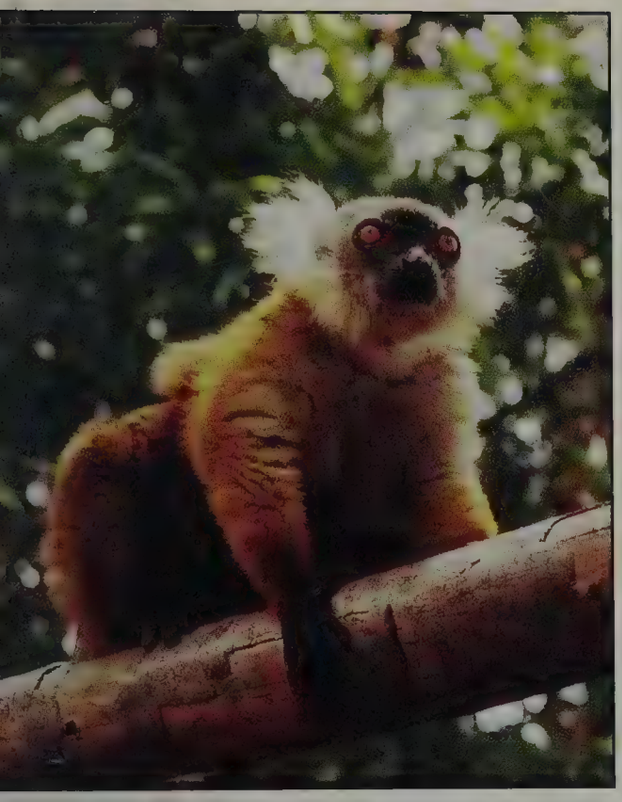
In 1973, a display of a dozen full-size, painted tepees was arranged for the grounds of the Southern Plains Indian Museum in Anadarko, Oklahoma. Among them were re-creations of old designs, including the Tepee with Battle Pictures, which was painted on canvas by Kiowa artist Dixon Palmer, again working from the illustration of Mooney's model. The tiny figures that had crowded the scale model suddenly assumed heroic proportions. The tepee's reappearance was greeted with enthusiasm, although Palmer claimed no relationship to the family of Little Bluff.

The following year, a new tepee inspired by the Tepee with Battle Pictures was adopted as the official tepee of the Black Leggings Warrior Society, a Kiowa veteran's organization that had been formed in 1958 and conceived as a direct revival of an old warrior society of the same name. Dixon Palmer's brother Gus, the organizer and commander of the society, explained that he got the idea for the tepee following a celebration held by the Fort Sill Museum in honor of Little Bluff. According to Palmer, Little Bluff, a distinguished warrior and chief, had himself been a member of the Black Leggings.

Dixon Palmer and another brother, George, painted the tepee. This time the tepee was not a reproduction of Mooney's model, but a new creation guided by oral traditions. The south side retained the black and yellow stripes representing war experiences, while the north side depicted the specific military deeds of present society members. Tanks, paratroopers, and bomber and fighter planes covered the surface. Shoulder patches and service ribbons were also reproduced, and the door flap was painted solid red in honor of the eight Kiowa soldiers who gave their lives while serving the United States of America.

Like the old tepees made of buffalo hide, the new tepee (now of Permasol sailcloth) has been renewed from time to time over the years, changing somewhat each time. Pictures of service patches honor Vietnam and Operation Desert Storm veterans, as well as those from earlier wars. The Kiowa still recognize that the tepee resembles Little Bluff's, but it is now known as the Black Leggings Tepee.

While the Black Leggings have created a tepee of their own, other versions of the Tepee with Battle Pictures continue to appear as artistic creations. In 1992, Vanessa Paukeigope Morgan produced a three-foot-high version of the tepee for an exhibit at the National Cowboy Hall of Fame in Oklahoma City. Morgan is a great-great-great-granddaughter of Little Bluff II. For her model, Morgan drew upon family history to depict military deeds, such as her great-grandfather Paukeigope's battle with the Ute. Respecting the Kiowa tradition that only men could reproduce such images, she instructed her son Seth in drawing the battle pictures. □



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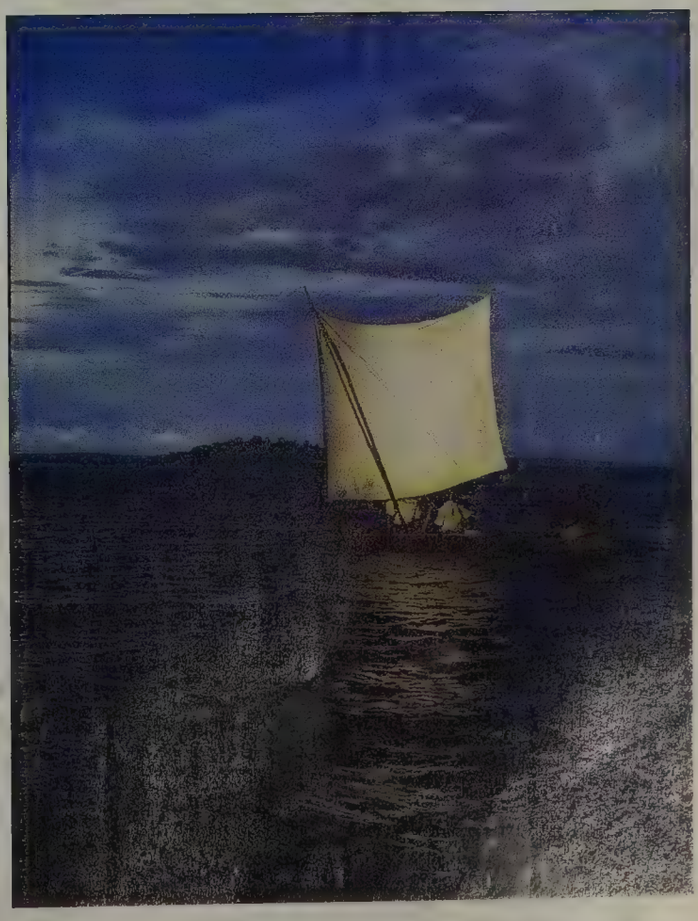


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The Unknown Bioengineers

Unsung Stone Age culture heroes transformed wild grasses into harvestable wheat

by Raymond Sokolov

In the sweaty, feverishly theoretical world of paleobotany, archeologists continue to sift sites of prehistoric villages and encampments hoping to establish where and when our forebears first took to eating and planting the edible grasses we call grains. This is a noble undertaking: the birth of agriculture and the settled life marks the beginning of true civilization. But archeological remains, by their very nature, are fragmentary, scattered, and hard to interpret. The task is especially difficult if the goal is to determine the patterns of social and economic life that precipitated (or resulted from) the discovery of grain agriculture.

Perhaps the complexity and inconclusive character of agricultural archeology are intrinsic to social science. By contrast, the answers given by the relevant hard science—biology—to the same questions, based on the same data, are comparatively clear and rational.

For botanists, the origin of grain agriculture does not present sticky, speculative enigmas about human nature and causation. The problem is clear. What genetic process did human beings bring to bear on wild grasses so as to convert them into grains suitable for agriculture?

There is no doubt that, over and over again, protofarmers selected appropriate varieties, saved their seeds, and planted them—to the exclusion of less desirable varieties—in fields. This is what we do today on a vast scale that merely continues the practice of our remote ancestors. Botanists, in any case, have no need to speculate about the social backdrop to events that interest them on the supremely logical level of genes and chromosomes.

Put baldly, the grains we have today were engineered by biogenetic tinkerers who somehow came to understand what characteristics were essential for farming grass. The analysis that these late Stone Age people made without any knowledge of formal biology is probably the most revolutionary and profound set of thoughts in human history.

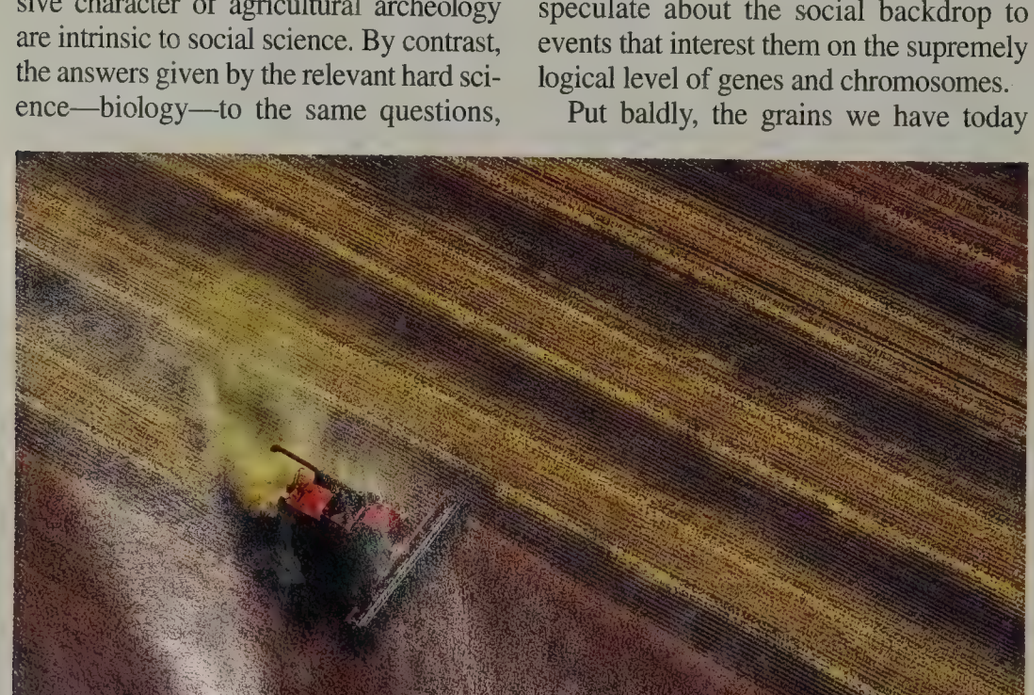
There is no recorded Newton for the theory of agriculture (if I may call it that). There were probably dozens of such Promethean culture heroes, in different locations and for each of the ultimate cereal grains. But in every case, the logic they came to was the same.

1. Agriculture is a deliberate exploitation of seeds. Put them in the ground, tend them until they mature, and harvest them. None of this is worth the trouble unless it is done in quantity and yields a reliable crop.

2. To produce cereal grass in quantity, these unsung Mendels needed to collect large amounts of seed. And that seed had to yield grasses with two essential characteristics: (*a*) seeds desirable for human diet, and (*b*) seeds that could be harvested all at once.

This second quality is the one that required the revolutionary human effort (since we can assume that the protofarmers found desirable wild grains in nature through random experimentation and made their selection well before they embarked on bona fide agriculture). What they had to understand—or imagine—was the concept of harvest itself.

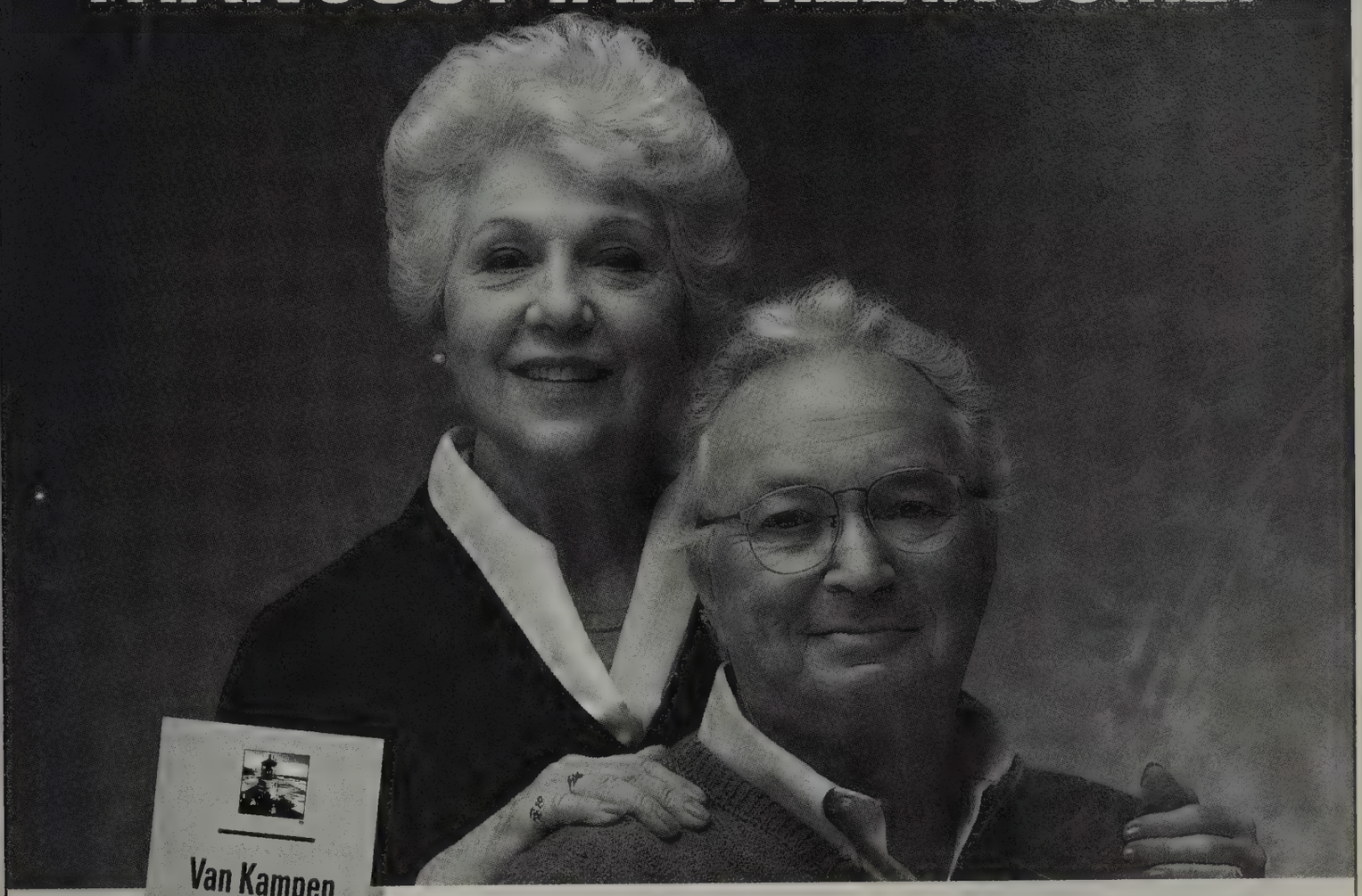
What is a harvest? It is a form of industrialized gathering-in of a single strain of cultivated plants all at one time. In a true harvest, the plants are easily accessible to the harvester (reaper)—all in the same place, in neat rows, without other plants (weeds) or physical obstacles to impede or confuse their collection. We call this



A combine threshes wheat near Billings, Montana.
Mike McCabe; Tony Stone Worldwide

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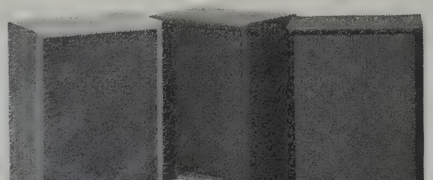


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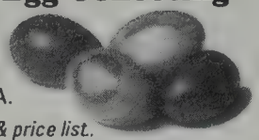
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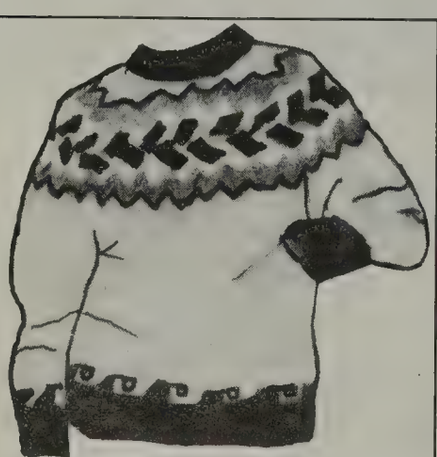
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arrangement a field. The plants growing i a field are a crop.

Plants cultivated in such a field are true crop if, and only if, the harvester ca pass through them in a single sweep takin what he wants and as little else as possible For this to happen, crop plants have to ma ture uniformly (at roughly the same time and conveniently.

Consider the reverse, the state of natur found by the James Clerk Maxwells o agriculture. Wild grasses put out seed early and late in the season. And individ ual grasses could put out many seeds o the same blade that matured at differen rates. Each mature seed eventually fell t the ground in order to continue its genetic mission and grow into another blade o grass. This falling to the ground, called shattering, is essential for the propagation of wild grasses but an absolute disaster fo cultivated grasses.

Why? Because shattering seeds are dif ficult if not impossible to retrieve. Re member that in the Book of Ruth, Boaz lets Ruth and Naomi "glean among the sheaves," meaning that he permitted them to scavenge in his fields, picking up grain left behind by the harvesters. These dropped seeds weren't worth his time, but the homeless women could have them if they were that desperate.

Boaz and his men had already done what all grain farmers do at harvest. They had moved through their fields, cutting the grain plants with seeds all ripe and still attached to the plant. Thus the grain could be easily and efficiently carried to a threshing ground, where the force of the wind or a beating by a flail would winnow out the desirable seed from the undesirable grassy chaff. Next stop was a mill where the hull and other fibrous parts of the seed would be removed and the rest, the good part, would be pulverized and stored.

In some grains (rice, barley, millet) a recognizable seed, not a flour, is the normal end product of the harvest, but the basic requirement of uniformly maturing, nonshattering seeds is universal. At some point in their history, all staple grains were hybridized with this goal in mind. Try to imagine, for instance, corn whose kernels ripened progressively from the top to the bottom of the ear over several weeks and dropped to the ground as they ripened. This would have serious survival advantages for a wild plant, since it would maximize the chances of some of the kernels hitting the ground on a day when the weather was favorable. But who would harvest such corn? It would never be

dy. Either most of the ear would be en or it would have dropped most of its nels.

nstead, somewhere in Central America g ago, clever people coaxed a grass to lve into *Zea mays,* making corn on the and survival possible for millions of ple, over many centuries.

There is no doubt that this kind of delib- e selection occurred all over the world. ven witnessed the last such miracle of type myself, in Minnesota in the late 0s.

Up until then, wild rice was truly wild. t really a true rice (*Oryza*), but an atic grass of the genus *Zizania,* it grew ts own accord (unplanted and unculti- ed) in northern lakes. Wild rice was nuniformly maturing, and it shattered the water. Local Indians had learned harvest it by making frequent passes through the lakes and flailing seeds that were ready to shatter into their canoes. One man would bend the grass over the canoe; the other would beat the seed heads. The same plants were "harvested" again and again. This type of harvest was really no harvest at all, but an organized form of gathering.

Enter some plant scientists and agronomic opportunists who searched high and low for naturally occurring plants with the right characteristics. They found non-shattering wild rice plants, cultivated them, and eventually had enough seed in hand to start "wild rice" agriculture on paddies and harvest this new crop mechanically.

Behind such useful hybridizations lies a basic genetic transformation of the plant. Botanists have analyzed these transformations, and when they can locate the origi-

Wheat Berries

Wheat berries are the whole, unmilled seeds of the wheat plant—the grain itself. Much can be said in favor of their nutritional qualities. But at least as compelling is their crunchy, serious flavor. They take a little more effort than rice and other more familiar grains, but the personality and novelty of wheat berries make them worth the trouble.

1 cup wheat berries

1. Soak wheat berries overnight in a large quantity of cold water, 3 to 4 quarts.
2. Bring to a boil and cook uncovered for 35 to 50 minutes. Taste after 35 minutes and every 5 minutes thereafter to determine whether the berries are soft enough for your taste. Eventually, the grains will begin to split. Be sure to stop them or you will get a weird mush. I prefer to stop much earlier, as soon as the grains are pleasantly chewy.
3. If possible, let stand, covered, for 15 to 30 minutes (or if not serving immediately, let stand until the wheat berries have returned to room temperature). Absorption of water will continue to take place.
4. Drain and serve.

Yield: 2¾ cups

Wheat Berry Kebabs

2 medium onions, peeled and chopped
Oil
1½ pounds ground lamb or beef
Pepper and salt
Cayenne
1 tablespoon ground cumin
1½ to 2 cups cooked wheat berries (see basic recipe)
1½ cups nonfat yogurt

1. Sauté the onions in enough oil to coat the bottom of a large skillet. When the onions are lightly browned, mix them with the ground meat, pepper, salt, cayenne, and cumin.
2. Gradually mix in the wheat berries, until you have the balance between grain and meat that you want. Since you've gone to the trouble of preparing the wheat berries in advance, you might as well use an appreciable amount. I favor at least 1¾ cups.
3. Form the meat–grain mixture into meatballs about the size of limes (smaller ones are fine too, but all the meatballs should be the same size so that they will cook uniformly). You should get around 2 dozen meatballs (double that amount if you make the small ones half the size of limes). Arrange them in the same skillet you used for the onions and set over high heat.
4. Turn the meatballs frequently so they brown on all sides. Lower heat and continue cooking, if necessary, until the meatballs are cooked to the desired degree of doneness. Remove from skillet to serving dish with a slotted spoon or tongs.
5. Remove skillet from heat and let cool for a few minutes. Then whisk yogurt into cooking juices and pour the resultant sauce over the meatballs.

Yield: 4 servings

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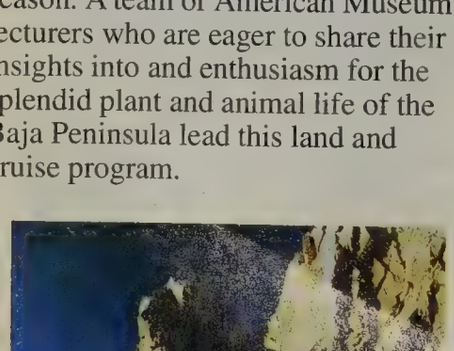
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nal wild form of the plant, they can trace the change and describe it in formal terms.

In this technical sense, each grain has its story hidden away in its cells and visible in its special adaptation to human needs. In their book *Domestication of Plants in the Old World: The Origin and Spread of Cultivated Plants in West Asia, Europe, and the Nile Valley* (Oxford, 1988), Daniel Zohary and Maria Hopf survey everything from grapes to beets to sesame and pistachios. But the most complex of these plant histories are those of the common grains. And of those, the great saga is that of wheat.

Wheat obviously matters. Our culture began with wheat. Neolithic civilization was based on a reliable supply of wheat and barley. Today wheat is the world's leading grain and accounts for "more than 20 percent of the total food calories consumed by man," according to Zohary and Hopf.

For the cook and the consumer, wheat distinguishes itself from all other grains because of its high gluten content. Gluten (or more accurately, gluten-forming proteins) produces elasticity in bread doughs, captures the carbon dioxide emitted by yeast fermentation, and thereby enables bread to rise. Of the four basic genetic varieties of wheat, only one can do this, and it resulted from the happy encounter of a true wheat and a related grass between 6000 and 5000 B.C., near the Caspian Sea. The result was *Triticum aestivum,* which went on to conquer the world. But the tortuous process that produced *T. aestivum* began with three wild wheat grasses.

T. monococcum, or einkorn, is a single-seeded, primitive plant whose hull adheres to the grain until it is pounded loose. Einkorn, once vital to neolithic agriculture in Europe and the Near East, barely survives today. It is a so-called diploid wheat, because it has fourteen chromosomes, double the basic complement of seven. Wild einkorn is brittle (shattering); cultivated einkorn is nonshattering.

Einkorn will not "mate" successfully with the two other naturally occurring wheat species, which are themselves not mutually fertile and produce sterile hybrids. Both *T. turgidum* and *T. timopheevi* are tetraploid (twenty-eight chromosomes, four times the basic seven). *T. timopheevi* grows only in Caucasian Georgia and is of no practical consequence to the outside world, nor has it ever been. *T. turgidum,* on the other hand, is the hero of our tale.

As a wild plant, it is brittle and hulled. The next stage up the ladder is called emmer (*T. dicoccum*), a cultivated, hulle cultivar of *T. turgidum.* As such, it was th ancestor crop of neolithic agriculture, as radiated outward in all directions from th Near East. In time, it was supplanted by naked, or free-threshing, variety that lo its hull during threshing. Old-fashione hulled emmer survives today as a mino crop in the Balkans, eastern Czechoslov kia, and Iran, and as a common crop Ethiopia.

Elsewhere, free-threshing *T. turgidu* usually called durum, or macaroni, whe (*T. durum*) took over. It is the wheat c choice for pasta and various flat breads c the Mediterranean and Near East. But i too, eventually ceded the field in mo places to a genetically more complicate and versatile high-gluten wheat, *T. ae tivum,* or bread wheat.

Bread wheat is a hexaploid wheat. It ha forty-two chromosomes or six times th basic seven. There is no wild form c hexaploid wheat. Genetic analysis ha shown that it is a hybrid of durum whea and a diploid wild grass of the Caucasus *Aegilops squarrosa.* This wheatlike plan has never been cultivated, but thrives as "colonizer of secondary, man-made habi tats and a common weed in cereal fields (Zohary and Hopf).

As such, it has not migrated west o Iran. So it must have lain in wait for culti vated durum wheat to reach the Caspia region 8,000 years ago, when these tw distant cousins linked genomes to produc a primitive, hulled form of bread whea known as spelt. Spelt is still cultivated as minor crop today and can even be found i U. S. health food stores. It is prepared as whole grain and tastes…healthful.

Scientists have repeated this process i the laboratory, crossing durum wheat and *A. squarrosa* to yield *T. aestivum.* Such hybridization between tetraploid whea and diploid *A. squarrosa* still occurs spon taneously in wheat fields in Iran today.

The spread of bread wheat nearly everywhere from the site of this obscure and unlikely coupling did not depend on the attractions of high-gluten rising alone Bread wheat was adaptable to a much wider growing range than tetraploid wheat. This (and the usefulness of low-gluten wheat in noodlemaking) explains the lingering importance of durum wheat in its traditional range, with bread wheat spreading far and wide beyond it.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.

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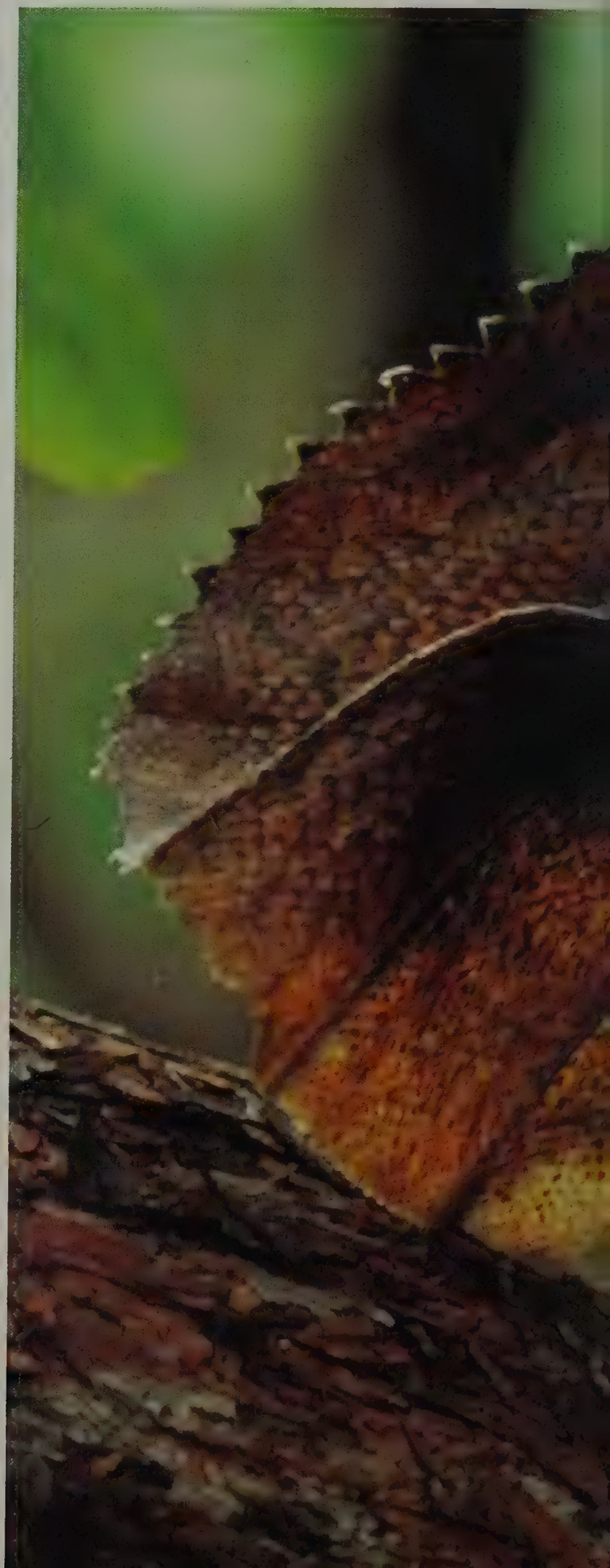
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King of the Frill

Photograph by Michael Fogden

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In the forests of northern Australia, a hissing *Chlamydosaurus kingii* displays its frill. Although it bears a striking resemblance to the fanciful, poison-spitting dilophosaurs of *Jurassic Park,* this three-foot-long lizard, called a frillneck, is no menace to humans since it feeds only on ants, grubs, caterpillars, and spiders.

Normally, the frill is folded back against the neck, but when the lizard opens its mouth wide, the frill springs open, supported by cartilaginous, riblike extensions of the hyoid bone (a small arch-shaped bone behind the lower jaw). The effect is startling and makes the lizard look larger and fiercer than it is—causing hawks, kookaburras, and other predators to think twice. To enhance the threat, the frillneck often rises on its hind legs, hisses, and swings its whiplike tail threateningly back and forth. If this fails, the lizard can disappear in a flash, running on its hind legs.

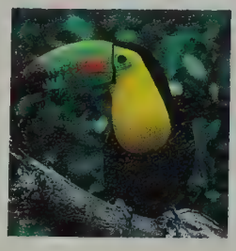
Richard Shine, a herpetologist at the University of Sydney, believes that one of the frill's primary functions has been largely overlooked. During the lizards' mating season in November and December, Shine observed adult males frequently displaying their frills while perched on tree trunks—a form of visual territorial marking. First the lizards lash their tails against the bark, sometimes producing an audible sound. Then they raise their bodies from the trunk, as if doing push-ups, and repeatedly open and close their frills and bob their heads. After a pause, the whole sequence is repeated. When one territorial male meets another, fights with fully erected frills are common—*R. A.*



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AUTHORS



E. D. Starin (page 44) reported earlier in *Natural History* on red colobus monkeys that live in the Gambia's Abuko Nature Reserve ("Monkey Moves," September 1981). In this issue, she explores the harmonious relations between the red colobus and two other monkey species that share the same habitat. Starin is currently surveying fluctuations among monkey populations in the Gambia's forest parks. She received her master's degree and doctorate from the City University of New York and is attached to the Department of Anthropology at University College, London. For additional reading she recommends *Primate Social Systems,* by Robin I. Dunbar (Ithaca: Cornell University Press, 1987) and *Primate Societies,* edited by Barbara B. Smuts et al. (Chicago: University of Chicago Press, 1986).

Simon Pollard (page 58) focuses his camera on a tiny sheep, a symbol of his native New Zealand. Although he is an arachnologist first, he is also a photographer and enjoys capturing his research subjects on film. Pollard's interest in natural history goes way back. When he was about five, he told his uncle, an expert in animal behavior, that bees *thought* in English. His uncle set him straight. Pollard attributes his current fascination with spiders to a well-developed sense of the macabre. After receiving his M.S. and Ph.D. from the University of Canterbury in Christchurch on New Zealand's South Island, Pollard completed a postdoctoral fellowship at the University of Virginia (where he did the work that led to his article on crab spiders). Now at the University of Alberta, he is currently a Killam Postdoctoral Fellow in the Department of Entomology and has recently traveled to Borneo to study and photograph tropical jumping spiders that have developed bizarre sexual ornamentations resembling antlers. Jumping spiders in the Philippines and water striders in China are next. To learn more about the feeding behavior of spiders, Pollard recommends *Biology of Spiders,* by Rainer F. Foelix (Cambridge: Harvard University Press, 1982).



professor of zoology at the University Vermont in Burlington, **Bernd Hein-** (page 50) has done much of his recent dwork in the forests of New England. has spent the past year on sabbatical in bin in the Maine woods, studying the l fauna and writing. Interested in in- s since he was a child, Heinrich is now ecialist in insect thermoregulation and recently written a book on the topic, *Hot-blooded Insects*. In previous arti- for *Natural History,* his subjects have n bees, squirrels, golden-crowned glets, and wild ravens ("The Ravens' st," February 1989). For more infor-

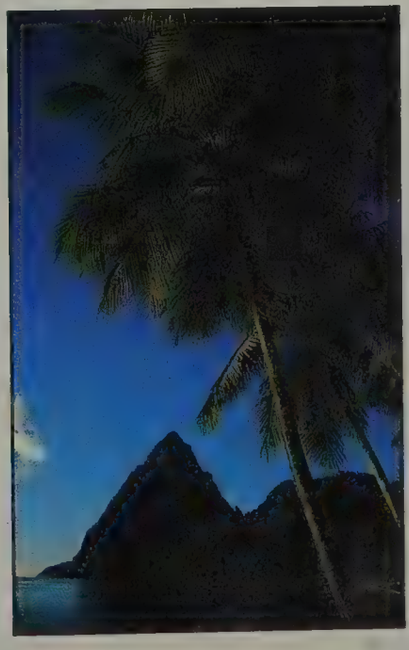


tion on animal intelligence, Heinrich commends *Animal Minds,* by Donald R. iffin (Chicago: University of Chicago ess, 1992) and *Cognitive Ecology, the nds of Other Animals: Essays in Honor Donald R. Griffin,* edited by Carolyn A. stau (Hillsdale: Lawrence Erlbaum As- cs., 1990). The natural history of ravens discussed in Lawrence Kilham's *The nerican Crow and the Common Raven* ollege Station: Texas A&M University ess, 1989) and Heinrich's own book on ese birds, *Ravens in Winter* (New York: mmit Books, 1989).



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Norbert Wu (page 66), a 32-year-old photographer, cinematographer, and author, had wanted to be a marine biologist since the second grade. Pursuing his interest at the Hopkins Marine Station at Stanford University, Wu took his undergraduate and master's degrees, then went on to advanced work at the Scripps Institution of Oceanography. "During my graduate-school days I discovered that doing hard-core scientific research was not for me. Its focus can be very narrow. Instead, photographing marine wildlife has been my way of seeing the world's oceans." Wu likes to quote John Steinbeck, who explored the Sea of Cortez in his own experiential, unscientific way: "We were determined not to let a passion for unassailable little truths draw in the horizon and crowd the sky down on us." Wu has worked as a still photographer aboard Jacques Cousteau's *Calypso* and is the author and photographer of adult and children's books, including *Life in the Oceans* (Boston: Little, Brown and Co., 1991), *Beneath the Waves* (San Francisco: Chronicle Books, 1992), and *Fish Faces* (New York: Henry Holt, 1993). For his sequence of the sea slug attacking the anemone in Monterey Bay, California, Wu used a Canon F-1, a 50mm macro lens, Oceanic 2001 strobes, and Kodachrome 64 film.



Michael Fogden (page 112) and his wife, Patricia, have worked together since 1968 in places as far afield as Uganda (warbler migration), Mexico's Sonoran Desert (competition between cattle and wildlife), and Costa Rica, where the couple have worked for fifteen years as free-lance writers and wildlife photographers. Michael earned a doctorate in ornithology from Oxford University's Edward Grey Institute and has worked as an ornithologist for the Sarawak Museum in Malaysia. As photographers, the Fogdens put their years of field biology to use, often collaborating with researchers on scientific projects. Among their many projects in the Central American rain forests, they have documented camouflage, warning coloration, and mimicry; the breeding strategies of frogs; the feeding behavior of snakes; and the co-evolution of flowers and the animals that feed on their nectar. The photograph of the frillneck lizard in this month's "Natural Moment" was taken with a Nikon F2 and a 105mm macro lens.

After repeatedly "tripping over" t
Tepee with Battle Pictures in Kiowa dra
ings, oral histories, photographs, mode
field notes, and conversations, **Canda
S. Greene** (page 68) decided to gather t
pieces of its story together. When h
eight-year-old daughter, Emily, aske
which of the many incarnations of t
tepee was the "real" one, Greene realize
that the rights to the tepee's design we
more important to the Kiowa than any
its manifestations. A specialist in Nor
American ethnology in the Department
Anthropology, National Museum of Na
ural History, Smithsonian Institutio
Greene has focused on nineteenth-centu
Plains Indian artists and their represent
tions of their cultures. For additional rea
ing she recommends the following book
originally published in 1898, 1945, an



1969, respectively: *Calendar History o
the Kiowa Indians,* by James Mooney
(Washington, D.C.: Smithsonian Institu-
tion Press, 1979); *The Ten Grandmothers,*
by Alice Marriot (Norman: University of
Oklahoma Press, 1985); and *The Way to
Rainy Mountain,* by N. Scott Momaday
(Albuquerque: University of New Mexico
Press, 1976).

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NATURAL HISTORY Vol. 102, No. 11 November 1993

COVER: *The creation of Lake Powell submerged many archeological sites along the upper Colorado River. Story on page 40. Photograph by Nicholas DeVore III; Photographers/Aspen.*

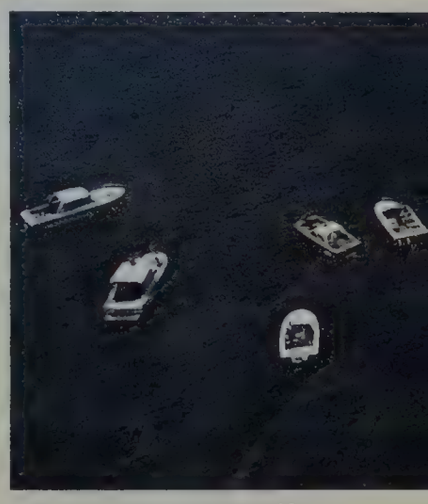
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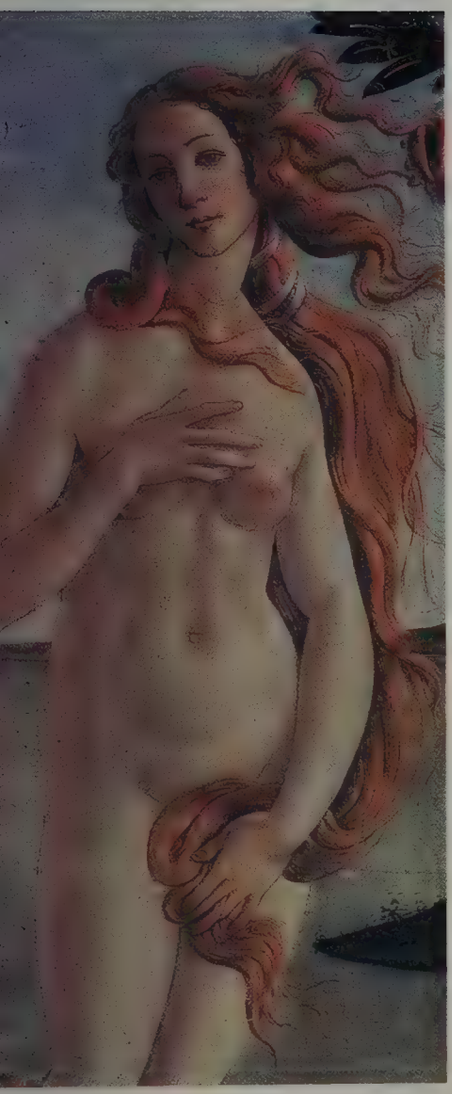
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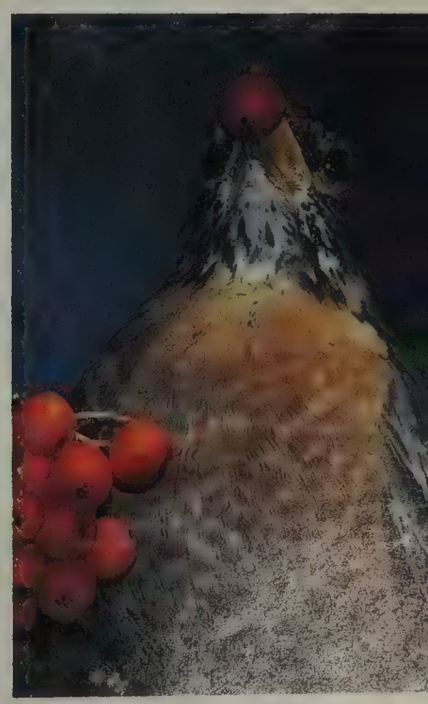
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LETTERS

IT'S A BIRD, IT'S AN AARDVARK, IT'S ...

I question Norell, Chiappe, and Clark's hypothesis ("A New Limb on the Avian Family Tree," September 1993) that *Mononykus* inhabited the same environmental niche as aardvarks or anteaters. With those relatively long legs, foraging on the ground would have been a very vulnerable and, at best, awkward proposition. If the authors are correct, then it is no wonder that *Mononykus* is extinct.

WILLIAM J. GASKINS
Zuni, Virginia

Although the authors emphasize *Mononykus*'s keeled sternum, *Mononykus* is illustrated on page 40 with no sternum at all. What then is the justification for saying this animal was birdlike?

With massive thighs and long legs, *Mononykus* would appear adapted to running (somewhat like an ostrich); without wings, it was certainly not a flyer. So what is a runner doing with digging limbs, or even tearing plants apart? Furthermore, the long neck does not seem to me compatible with the short, stubby, and powerful pectoral limbs' being used for foraging. It doesn't seem possible that food could be passed from the forelimbs to the mouth. Even *Tyrannosaurus rex* could presumably reach its head with its relatively short forelimbs.

ROBERT B. CHIASSON
Professor Emeritus, Veterinary Science
The University of Arizona, Tucson

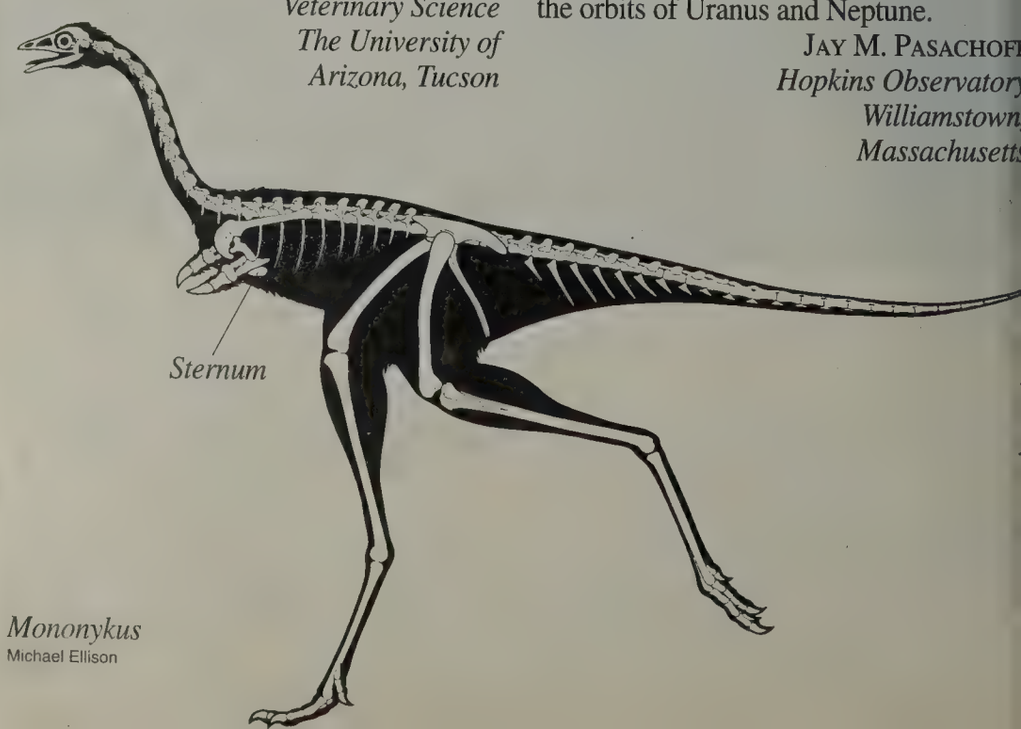
THE AUTHORS REPLY: *Mononykus* differ from all other flightless birds in that it wings are not vestigial. The massiveness and hypertrophy of several of the forelimb structures indicate that it used its forelimbs for a specific, active function. Our inference about its habits—as we wrote—is our best guess. We do not see *Mononykus* as vulnerable to predation because the proportional relation of the bones in the hindlimbs indicates that it must have been a high-speed runner.

As for the sternum, the illustration (reproduced below) shows the caudal end of it projecting below and behind the olecranon process of the ulna. The sternum is keeled, but very small in proportion to the overall size of the animal. In any case, the rationale for placing *Mononykus* within birds is not just based on the keeled sternum; its hind limbs, vertebrae, forelimbs and skull support this hypothesis as well.

WHO NEEDS PLANET X?

Gail Cleere's interesting note on Planet X ("Celestial Events," June 1993) has now been enhanced by a new analysis of the masses of the giant planets by Myles Standish of the Jet Propulsion Laboratory (*Astronomical Journal*, May 1993). On the basis of *Voyager* data, Standish finds that the value of Neptune's mass differs by 0.5 percent from our best previous estimate and that this change is enough to eliminate the need to invoke Planet X in predicting the orbits of Uranus and Neptune.

JAY M. PASACHOFF
Hopkins Observatory
Williamstown, Massachusetts



Mononykus
Michael Ellison

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Lightning Sickness

In a tiny Peruvian village, a woman pays for her nonconformity

by Winifred L. Mitchell

When lightning struck Nora's house in the high Andean community of Utani, her neighbors were not surprised. Lightning is not a random event for these Aymara-speaking villagers but a punishment from God and a direct sign of his disapproval. Nora's house was partly burned, and a smoke-damaged room had to be closed off, until it could be magically purified and repaired. This would take some time because Nora, a thirty-four-year-old widow, barely had the resources to meet the demands of everyday life for herself and her three children.

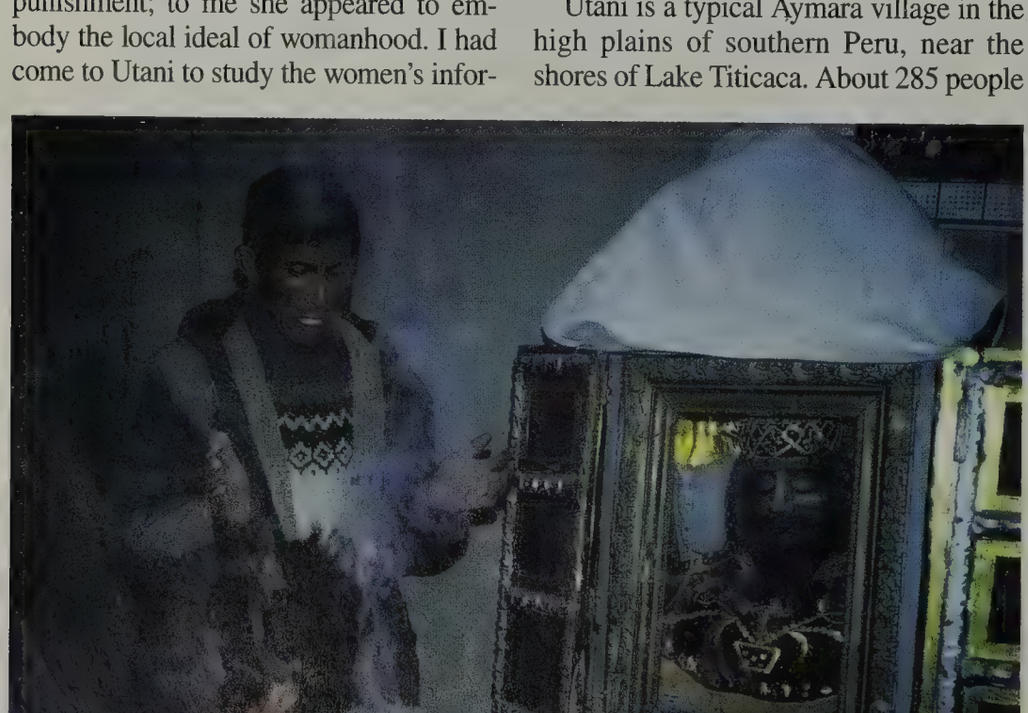
I was puzzled when I learned that everyone agreed that Nora deserved her punishment; to me she appeared to embody the local ideal of womanhood. I had come to Utani to study the women's informal prestige system, and as I understood its workings at the time, other women should have respected Nora for keeping her family and home together in the face of poverty, widowhood, and other calamities. A good woman does not give up; she perseveres by means of hard work, careful management of scarce resources, and strength of character. But in one important respect, Nora did not conform to the ideal of womanhood. She had refused to endure her husband's philandering. This act, the villagers believed, plus her general inability to get along with her neighbors, had brought the wrath of both God and the Andean spirits down upon her house.

Utani is a typical Aymara village in the high plains of southern Peru, near the shores of Lake Titicaca. About 285 people make up the community's 55 household On their landholdings, covering slightl more than one square mile, they raise mo of their food crops—potatoes, quinoa high-protein grain), and barley—and als keep small herds of sheep and cattle an some chickens and pigs. Scattered amon the tiny plots of crop and pasture land a sod houses with tin or thatched roofs.

Situated thirty miles from Puno, a sma city on a bay of Lake Titicaca, Utani lack electricity, piped water, shops, clinics, im proved roads, and other modern service The village is fairly close to the road run ning south from Puno, however, and buse and trucks stop anywhere along the road t take people to nearby market town where they can sell some crops. Villager can also travel farther away to the Peru vian coast; men especially spend a fe months a year there as wage laborers Cash from such jobs, more than earning from the sale of produce, covers a family consumer expenses.

Men's and women's social roles ar shaped partly by the men's contact, a wage earners, with the broader Peruvia society and partly by ancient Andean prin ciples. People of both sexes (and all ages agree that the man is the ultimate decisio maker in the home, the acknowledge head of the household. He is the perso who receives recognition and prestig within the community for the economi standing of the family. Because they ar wage earners as well as agricultural pro ducers, men are credited with being th sources of prosperity. This is true ever though a good woman works beside he husband in the fields and manages the en tire operation while he is away on th coast.

Both women and men stress that thei interdependence is vital for a family's sur



Aymara villagers pray and burn incense in front of a holy statue to purify a room that was struck by lightning.
Winifred L. Mitchell

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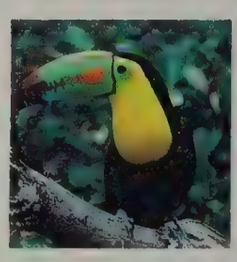
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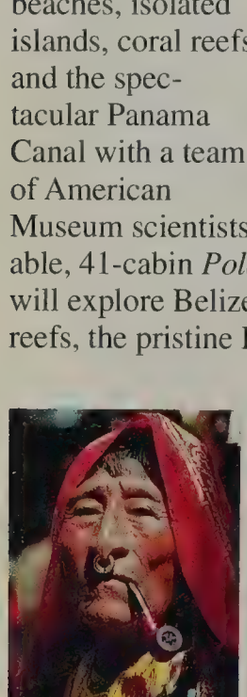
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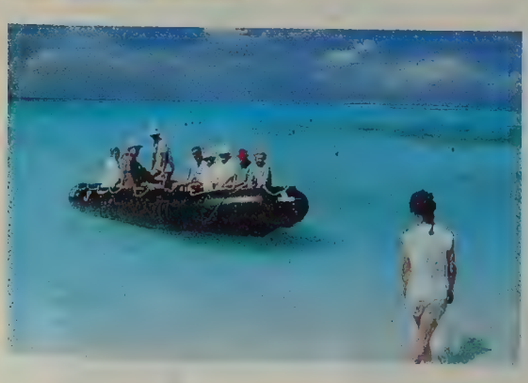
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vival. They recognize the important economic contribution of women to the work of the household, in both domestic tasks and in the raising of crops and animals. I was told, "a good woman's hands are never idle." But a woman has little control over what may be the scarcest resource in her society—a cash income. She may earn a little money as a vendor or laborer, but her earnings cannot compare with what a man can earn. Furthermore, the villagers do not really acknowledge a woman's work in evaluating her. Nearly all women work hard, but what really separates one woman from another are her character traits.

According to Aymara women, a good woman is one who keeps her family together at all costs and doggedly suffers life's tribulations, whether their source is an abusive or philandering husband, illness, poverty, or bad luck. The women of Utani express this value by saying that the woman is the soul of the family. "If the wife dies," they say, "the hearth grows cold and the children scatter."

When I asked women to rank one another on the basis of being respected as a good woman, Nora was consistently ranked near the bottom. Women explained to me that she had "killed her husband." As the tale unfolded, I learned that she was believed to have caused his death by failing to tolerate his philandering and abuse—in short, by refusing to suffer.

The turning point for Nora came when her husband, Miguel (all names are pseudonyms), returned from a long stay on the coast. Instead of coming directly home, bringing much-needed cash for the family, Miguel went to visit his mistress, Carmen, whose husband happened to be in jail under suspicion of cocaine trafficking. Miguel brought her gifts of cash and special foods from the coast. Nora soon became suspicious, however, and went looking for Miguel, catching him red-handed with Carmen.

That Nora learned of the relationship is hardly surprising, since Carmen was her next-door neighbor, with only 200 yards of field and pasture separating the two houses. Moreover, in a tiny village like Utani, everyone seems to know everyone's business. Nevertheless, direct confrontations are usually avoided by a combination of discretion and forbearance. In this case, however, a fight ensued, with Nora, Carmen, and Miguel battering each other with threshing poles.

Somehow, Miguel was hit on the head, but no one seemed to know or care who had hit him. Nora was deemed guilty, n because she hit her husband (although sh may have) but because she then refused take him in, forgive his behavior, ar nurse him back to health. Perhaps daze by the blow, perhaps depressed or drun Miguel wandered the fields. After a fe days, he killed himself, deliberately or a cidentally, by drinking a bottle of aldrin, particularly toxic pesticide. Nora wa blamed for his death.

In contrast, Carmen was not blamed f these events and received higher marks f virtue because she did not let the incide ruin her family. She was probably beate for her infidelity, but she remained ma ried and maintained her customary hous hold life, while Nora became a poverty stricken widow with little support eve from her relatives.

In spite of Nora's low standing in th community, the people of Utani responde with attention and concern when lightnin struck her house. According to their belie the entire village shared responsibility f bringing about reconciliation among com munity members and with the cosmos. S everyone came to Nora's house for blessing and purification ritual. To grac the occasion, an especially holy statue wa brought from a shrine in a neighborin community, and all present (including me came forward to kneel and pray for ha mony. Holy water, collected from th church in the market town, was sprinkle in the house, and incense and specia prayers were used to purify the room dam aged by the fire. Following these ritual Nora and her kin and neighbors served festive lunch for which a sheep had bee slaughtered.

After the ceremony, Nora's life went o much as before. The village women con tinued to cite her as a favorite example o how a woman should not behave. Nor herself moped a great deal about her ba fortune, but never gave any indication, a least to me, that she regretted her actions She rested a lot and complained of head aches, which she attributed to smoke in halation during the lightning fire. She de scribed herself to me as tired and old although she was only thirty-four. An el derly, wise woman in the community tol me that the headaches were a bad sign "That is the lightning sickness," she de clared. "There is no cure for it. She will b dead in three years."

Winifred L. Mitchell is an assistant profes sor of anthropology at Minnesota's Man kato State University.



A joyless tattoo mournfully resounds across time itself.



Civil War enthusiast Brad Austin remembers his first visit to Vicksburg, Mississippi.

At first, it's simple to be deceived by the powerful beauty of the battleground. Along the green ridges and bluffs, the statuary is virtuously gallant, the monuments quietly reverent.

One cannot help but idly think of this as a site for picnics with wicker hampers or a place for children to jubilantly fly kites made of paper and twine.

Only then does the harrowing gravity of Vicksburg overcome your heart with the suddenness of cannon fire. The screams of fallen men and shattered horses resonate through the wooded hills and hollows. The imagination starts hearing the muffled cries of a city forced to live in hillside caves, dining on mule meat as 47 days and nights of cannonade rained through the smoke-filled sky.

As I stood there, with daylight giving way to dusk, the delicate line between banner-snapping glory and heartrending sorrow had first blurred, then evaporated.

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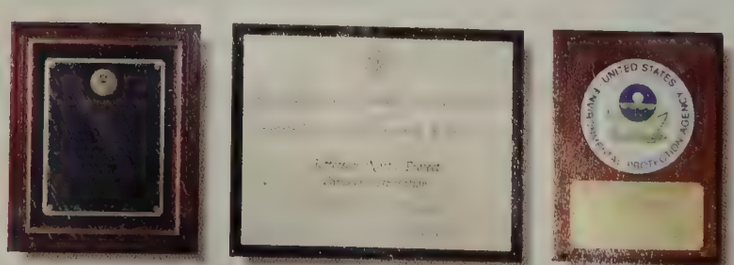
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With all this talk about reduction, there are a few things we're proud to say we've expanded on. One of these is alternative fuel technology. Chrysler Corporation already has electric, natural gas and methanol fuel vehicles for sale today. Which also puts us ahead of government guidelines.

While we're proud of our achievements so far, there's still room for improvement.

We'll keep working for a day when the only by-products from our plants are more of these awards.

After all, the whole world is watching.

CHRYSLER CORPORATION

Who Are the Jews?

Genetic studies may resolve whether modern Jews are descendants of ancient Semites or of converted Gentiles

by Jared Diamond

The small yellow bird ahead of me drew my attention by its manner of vigorously pumping its tail up and down as it walked. That gave it away as a yellow wagtail, familiar among biologists as a textbook case of evolution in action. At some time in the past, from some Old World center of origin, an ancestral wagtail population spread out to colonize most of Eurasia, from England east to the Bering Strait and from Lapland south to Egypt. The resultant scattered populations all adapted to their new homelands through natural selection. In consequence, the bird's color pattern now varies geographically, permitting birdwatchers to identify a wagtail's place of birth at a glance. Although the individual I was following belonged to a race that breeds in Europe, I was watching it on its wintering grounds in Israel, where a different race breeds and where several wagtail populations now commingle after their ancient diaspora.

The site of this commingling was a famous landmark in another famous diaspora: the clifftop fortress of Masada. There, in the year A.D. 73, during the disastrous Jewish revolt against Roman rule, a group of 960 Jews, after having withstood a year-long siege by a Roman army of 15,000, finally committed mass suicide on the night after their defense wall had been breached. The extreme dryness of the Dead Sea climate preserved features of the battlefield as if it had been excavated only yesterday. Those still-visible features include potsherds used as lots and cast by the trapped Jews to decide the order of their suicide, the eight camps where the besieging Romans had lived, and the ramp that Roman engineers had constructed to reach the summit. As I stood there on a burning hot day in 1992, I could almost feel the ferocious determination that had driven the besieged to hold out for so long in their hopeless situation and that had driven the Romans to mount such a huge effort to crush such a small band of rebels. Jews who survived the crushing of the revolt elsewhere in Palestine scattered over much of the ancient world.

On the day I visited Masada, humans as well as wagtails were commingling after their respective diasporas. I was making my first trip to Israel, after my Jewish ancestors had somehow ended up in Eastern Europe before emigrating to the United States. With me on Masada was a group of Ethiopian Jews, a formerly isolated population that underwent a well-publicized evacuation to Israel in the 1980s and 1990s. For the first time in perhaps two thousand years, close contact between the Jews of Ethiopia, Eastern Europe, and other regions has resumed.

The resettlement of formerly scattered groups of Jews in Israel is another textbook case of evolution in action. Not only wagtails but also humans adapt to local climate through natural selection. Although the Jews have been scattered for only a few thousand years, their faces often reflect their scattered homelands. The evolutionary changes underlying those different faces can be much more easily deciphered than changes underlying wagtails' various color patterns, since we know far more about human genetics than about wagtail genetics. How are we humans molded by our environments?

Genetic studies of Jews may resolve a major, long-standing historical debate. Are the scattered groups of modern Jews really the modified descendants of ancient Jews of the Old Testament? Or are some groups of them instead converted Gentiles (non-Jews), and others so diluted by intermarriage with Gentiles that little remains of their originally Jewish genes? In his book *The Thirteenth Tribe,* Arthur Koestler pressed the view that the Jewish origins of the Ashkenazim (the Eastern European Jews, constituting most Jews alive today) are a myth. Instead, Koestler argued that the Ashkenazim are descendants of a Turkic tribe, the Khazars, who converted to Judaism in the eighth century A.D. In Koestler's words, "This would mean that their [the Ashkenazim's] ancestors came not from the Jordan but from the Volga, not from Canaan but from the Caucasus, once believed to be the cradle of the Aryan race; and that genetically they are more closely related to the Hun, Uigur, and Magyar tribes than to the seed of Abraham, Isaac, and Jacob." This view is controversial, to put it mildly.

There are also practical reasons for interest in Jewish genes. The state of Israel has been going to much expense to support immigration and job retraining of Jews who were persecuted minorities in other countries. That immediately poses the problem of defining who is a Jew. For example, a debate is going on right now in Israel concerning policy toward Ethiopia's remaining would-be immigrants who identify themselves as Jews. Are they descendants of ancient Jews, as they maintain, or are they descendants of converted Africans, as their physical appearance might suggest?

As background for understanding these questions, let's begin with a crash course in Jewish history. The earliest surviving accounts of the Jews date from the second millennium B.C., when Jews were one of many Semitic peoples in the Near East. During the tenth century B.C., their political power reached its height, under King David and King Solomon, in a state that was eventually destroyed by the Assyrians and Babylonians. Nebuchadnezzar's deportation of much of the Jewish population to Babylon in 586 B.C. forcibly initi-



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ated the Jewish Diaspora. It continued more peacefully in Greco-Roman times, as Jews spread over most of the Mediterranean Basin as traders and farmers. Further, violent diasporas took place when the Romans crushed Jewish revolts in A.D. 73 and 135 and scattered the survivors. At some uncertain point after those migrations, Jewish communities became established as far afield as Yemen, India, Ethiopia, and even China. For example, by A.D. 300 at the latest, Jews had reached Yemen, which was actually a Jewish kingdom for much of the fifth and early sixth centuries A.D.

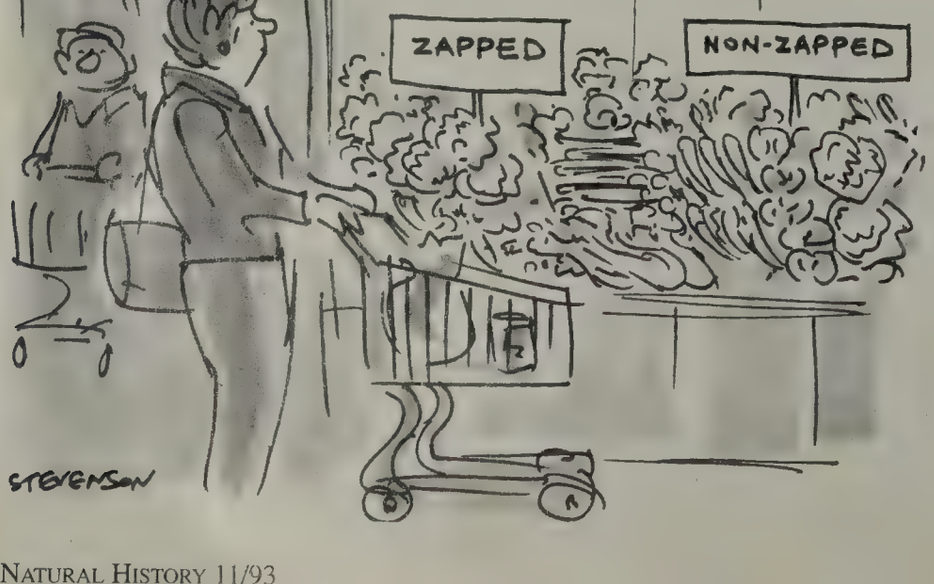
In northern Europe, Jewish merchants under Charlemagne began settling in France and the Rhineland in the eighth century A.D. Beginning about A.D. 1290, however, Jews were expelled, in turn, from England, France, and Germany, and finally, in 1492, from Spain. The exiles from Spain fled mainly to North Africa and became today's Sephardic Jews, while those from northwestern Europe moved eastward to Poland, Lithuania, and the Ukraine to become the Ashkenazic Jews. In the 1880s, Jewish emigration from Eastern Europe to the United States accelerated, culminating in the decade 1900–1910, when more than 100,000 Jews annually (including my grandparents) reached the United States from Russia alone. Most of those who remained in Eastern Europe were killed in the Holocaust during World War II. Following the establishment of the state of Israel in 1948, millions of Jews surviving elsewhere in Eurasia and North Africa emigrated to Israel; virtually all of Yemen's 50,000 Jews were air-lifted to Israel in 1950 by Operation Magic Carpet. Among the largest of these emigrations is that of Russian Jews, still in progress. Today, about 82 percent of the world's Jews are descended from Ashkenazic Jews, 11 percent from Sephardic Jews, and 7 percent from Oriental Jews.

In addition to these population movements, Jews have become Gentiles and vice versa through conversion and intermarriage. No one questions that at least the Khazar and Yemenite rulers converted to Judaism, or that there were also conversions of Moroccan Berbers, other Mediterranean peoples, and Ethiopians. What remains unclear is whether the conversions involved much of these populations or were mainly limited to the ruling classes. Similarly, intermarriage is extensive now: about one-third of American and European Jews today are marrying non-Jewish spouses. But how much intermarriage was there in the distant past? To what extent have conversions and intermarriage diluted the original Jewish contribution to the genes of those identifying themselves as Jewish today?

Before modern methods of identifying single genes became available, anthropologists tried to pinpoint Jewish relationships by the traditional anthropological indices of head measurements and skin, hair, and eye color. While these characteristics are strongly influenced by genes, they each have the disadvantage of being under the control of many genes rather than of just one. In addition, the genes involved and their mode of inheritance are uniden fied, and some of these traits (especial skin color) may fluctuate with enviro mental conditions (such as exposure sunlight) during a person's life. At a rate, each group of Jews resembles, each of these traditional anthropologic traits, the Gentile "host" populatio among which that Jewish group lives. Ju as ethnic Germans tend on the average be more fair-skinned than ethnic Egy tians, Ashkenazic Jews also tend to b more fair-skinned and more likely to hav blond hair and blue eyes than a Sephardic Jews from the Mediterranea In turn, the Jews of Ethiopia and India ar on the average, darker-skinned tha Mediterranean Jews, just as ethn Ethiopians and Indians are usually dark than Egyptians. Does this suggest exte sive intermarriage and conversions?

This tentative conclusion seemed to b reinforced by studies of some of the sin gle-gene markers that began to becom available in the 1940s. For instance, a ge netically controlled deficiency of the en zyme G6PD (glucose-6-phosphate dehy drogenase) is rare among Ashkenazi Jews and Eastern European Gentiles, bu common among Mediterranean Jews an Gentiles. In addition, a specific variant o the enzyme phosphoglucomutase occu with a frequency of only about 21 percen among both the Ashkenazim and Easter European Gentiles, but at a higher fre quency of 26 to 32 percent among bot Mediterranean Jews and Gentiles. As sti a third example, each Jewish population ABO blood groups (a set of geneticall determined chemicals that reside on th surfaces of our red blood cells and othe cells, and whose relative frequencies var greatly around the world) resemble thos of the Gentile host population. Yemenit Jews and Arabs share a low frequency o the gene for blood group B (about 8 per cent); Ashkenazic Jews and Germans, medium frequency (about 13 percent); an Bombay Jews and Indians, a high fre quency (about 20 percent). Even withi Europe itself, those countries with hig frequencies of the B gene in their Jew tend to be the ones with high frequencie in their Gentiles.

On the face of it, these facts seem t suggest that being Jewish is more a matte of belief than of genes. A 1975 book ex pressed this view with the attention-grab bing title *The Myth of the Jewish Race* Perhaps emigrant Jews in the past settle down in their new homelands, made loca converts, and intermarried on a massive



Why We Need A Smaller U.S. Population And How We Can Achieve It

We need a smaller population in order to halt the destruction of our environment, and to create an economy that will be **sustainable** over the very long term.

We are trying to address our steadily worsening environmental problems without coming to grips with their root cause -- overpopulation.

If present immigration and fertility rates continue, our population, now over 254 million, will pass 400 million by the year 2050 -- and still be growing rapidly!

All efforts to save our environment will ultimately be futile unless we not only halt U.S. population growth, but reverse it, so that our population can eventually be stabilized at a **sustainable** level -- far lower than it is today.

The Optimum U.S. Population Size

The central issue is surely this: **At what size should we seek to stabilize U.S. population?** Unless we know in what direction we should be headed, how can we possibly devise sensible policies to get us there?

The size at which our population is eventually stabilized is supremely important because of the effect of sheer numbers of people on such vitally important national goals as a healthy environment, and a sustainable economy.

We believe these goals can best be achieved with a U.S. population in the range of 125 to 150 million, or about its size in the 1940s. This optimum size could be reached in about three to four generations if we do two things now that are well within our grasp.

How To Get There

1. **Reduce annual immigration to about 200,000** so that it is in rough balance with emigration (out-migration). Then, immigration will no longer contribute significantly to our population growth, as it does now.

2. **Lower our fertility rate** (the average number of children per woman) from the present 2.1 to around 1.5 and maintain it at that level for several decades. We believe that non-coercive financial incentives will be necessary in order to reach that goal.

If almost all women had no more than two children, our fertility rate would drop to around 1.5, because many women remain childless by choice, or choose to have not more than one child. **We promote the ideal of the two-child maximum family as the social norm, because that is the key to lowering our fertility.**

Incentives to Lower Fertility

NPG proposes these incentives to motivate parents to have no more than two children:

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- Give a Federal income tax credit **only** to those parents who have not more than two children. Those with three or more would lose the credit entirely.
- Give an annual cash grant to low income parents who pay little or no income tax, and who have no more than two children. Those with three or more would lose the cash grant entirely.

Two Vastly Different Paths Lie Before Us

With the reductions in immigration and fertility we advocate, our nation could start **now** on the path toward a sustainable, and prosperous, population of 125 to 150 million.

Without such a program, we are almost certain to continue our mindless, headlong rush down our current path. That path is leading us straight toward catastrophic population levels that can only devastate our environment, and produce universal poverty in a crowded , polluted nation.

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scale. If so, modern Jews would be a genetic grab-bag of separate peoples now sharing a common religion.

Yet other recent genetic studies yielded the opposite conclusion. In their fingerprints, Rhesus blood group frequencies, haptoglobins, and several enzyme markers, Ashkenazic Jews resemble Sephardic and Yemenite Jews and differ from Eastern European Gentiles. Furthermore, in these respects Jews resemble many Gentile peoples of the eastern Mediterranean, such as Samaritans, Armenians, Egyptian Copts, and Syrian, Lebanese, and Palestinian Arabs.

If one had only this latter evidence, one would conclude that Jews are a typical eastern Mediterranean people who have carried their Mediterranean genes with them and remained distinct from the new groups of local Gentiles they encountered as they drifted away from the Mediterranean. Jewish conversions of non-Mediterranean peoples, and intermarriage with them, would have been slight. The supreme irony of recent Arab-Israeli conflicts would then be that they have been internecine wars between peoples joined by blood and by their closely related Semitic languages. (In Merritt Ruhlen's *Guide to the World's Languages,* Hebrew and Arabic are assigned to the same sub-sub-sub-subgroup of the Afro-Asiatic language family.) But how is the evidence of fingerprints and Rhesus blood groups to be reconciled with the contradicting evidence of skin color and ABO blood groups?

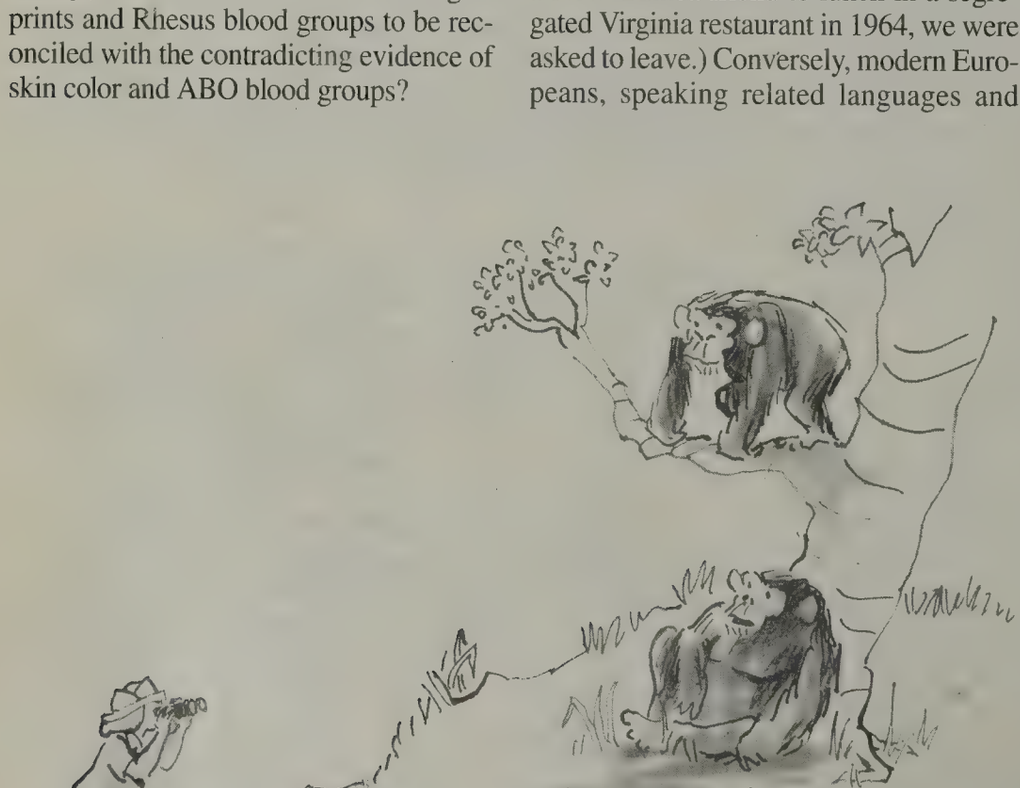
The implicit assumption in our reasoning so far has been that genes trace ancestry and nothing else. If my genes are similar to your genes, we must be related; if they're different, we must be unrelated. More specifically, we've tacitly assumed that blood groups and other genetic markers are what are known as selectively neutral traits: straightforward indicators of genetic origins, uninfluenced by natural selection and passed from generation to generation with unchanged frequencies.

But of course that's not necessarily true. Among Darwin's most important insights was his concept of natural selection: depending on the environment, certain traits permit an animal to survive (and to pass on its genes) with higher probability than do other traits. Thus, two populations derived from the same ancestral population may diverge genetically in different environments, while populations from different ancestral stocks will tend to converge in the same environment. One of the most familiar human examples involves skin color: tropical peoples tend genetically to have darker skins than temperate-zone peoples. For instance, equatorial West Africans, South Indians, and New Guineans resemble each other in their dark skins. (Africans and New Guineans are also sufficiently similar in hair form and other respects that, when I tried to take a New Guinea friend to lunch in a segregated Virginia restaurant in 1964, we were asked to leave.) Conversely, modern Europeans, speaking related languages and probably sharing a common genetic a cestry, exhibit a striking gradient in sk color from north to south. Perhaps natu selection, rather than conversion and inte marriage, similarly accounts for the nort to-south gradient in skin color of Jews.

Another argument for natural selecti is the rate of G6PD deficiency amo Jews and their "host" populations. As most warm areas of the Old Worl malaria was formerly a major health pro lem around the Mediterranean. In r sponse to this chronic, life-threateni danger, Old World peoples evolved va ous "genetic antimalarials," of which t best known is the sickle-cell hemoglob of Africans. These genetic traits off some protection against malaria—but at cost, usually a tendency toward anem (see my article in the February 1989 iss of *Natural History*). While the benef outweigh the costs in heterozygotes (pe ple inheriting the gene from just one pa ent), the anemia often proves to be cri pling or even fatal in homozygotes (peop inheriting the gene from both parents). malarial environments, the antimalari benefits to the more numerous heteroz gotes offset the severe disadvantage to t far less numerous homozygotes. Tak away malaria, though, and all benefits the gene disappear.

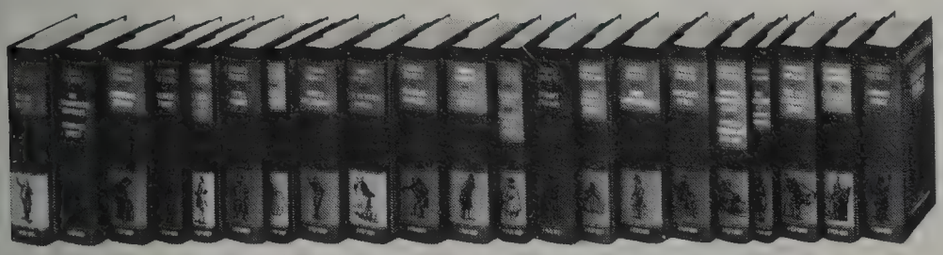
An example of that effect of natural s lection is provided by today's U. S. black The antimalarial sickle-cell gene in the is less prevalent than it is in African popu lations from which we know that blacks the United States are descended. Where Ashkenazic Jews might conceivably b converted Khazars, American black aren't "converted" whites or Native Ame icans lacking the sickle-cell gene. How ever, their low frequency of the gene cou reflect extensive mixing with whites Native Americans, and that was how was initially interpreted. Eventuall though, other African genetic markers be came available, and in their frequencie American blacks proved closer to Africa blacks than to American whites, sugges ing that their genetic heritage was not s mixed as had been assumed. Sickle-cell frequency in New World blacks is als lower in malaria-free regions than in re gions with malaria. In the few centurie that blacks have been in the Americas, na ural selection has apparently already elim inated some of their original heritage sickle-cell genes.

For Mediterranean peoples such as th original Jews, G6PD deficiency rathe than sickle-cell is one of the leading ge



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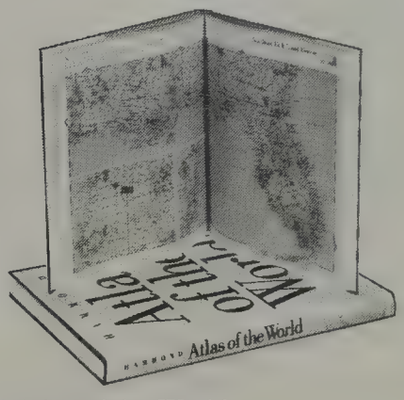
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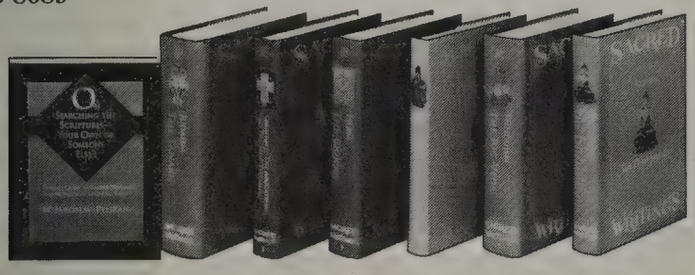
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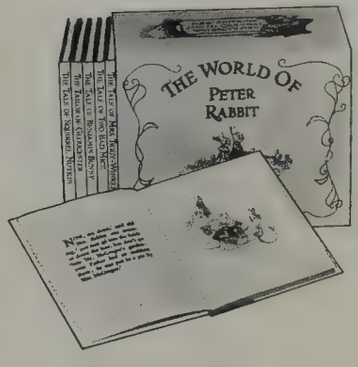
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netic antimalarials. Nevertheless, the reasoning is otherwise similar to that in the case of New World blacks. When Jews arrived in malaria-free Eastern Europe, they would have tended gradually to lose the G6PD-deficiency gene, even if they had never intermarried or made converts. That Russian and German Gentiles also lack this gene does not mean that the populations are related; the loss of the gene could have developed independently, as has the similar skin pigmentation of black Africans and New Guineans.

But what about the ABO blood groups, which were formerly assumed to be neutral genetic indicators of racial origins? They too are subject to natural selection because they resemble (are mimicked by?) the antigens of some bacteria. In consequence, people with certain ABO blood types seem less able to develop antibodies against certain bacteria, and more susceptible to diseases caused by those bacteria, than people with a different ABO blood group. The evidence is strongest for smallpox susceptibility of people with blood group A (see *Natural History,* February 1990, "A Pox upon Our Genes"). Relatively speaking, blood groups B and O may be "genetic antismallpoxicals." There is also suggestive evidence that the ABO blood groups affect resistance to bubonic plague, cholera, and syphilis.

If those infectious diseases had always been uniformly distributed over the world's peoples, they wouldn't have molded ABO blood groups to local geography. However, as every traveler is well aware, different diseases sprang from different regions: cholera from Southeast Asia, yellow fever from Africa, and so on. Thus, over thousands of years, the ABO blood groups may have adapted to the local disease environment, just as skin color adapts to local climate and genetic antimalarials adapt to the local presence or absence of malaria. From that perspective, it's unsurprising that Mediterranean peoples differ from ethnic Poles in their ABO blood groups, or that Jews transplanted to Poland eventually came to resemble Poles in their ABO blood groups (as well as in their skin color and lack of genetic antimalarials).

Not all genes, though, are strongly influenced by natural selection. As one example, take fingerprints, classified according to the relative frequencies of the different types of wavy lines on your fingers (termed loops, whorls, or arches). To understand the differences, lightly press your own finger on an ink pad, then press your finger on paper, and look at the resultant pattern. The "arches" are the very gently bent lines; the "loops" are the deeply bent lines; and the "whorls" are the lines closed in a circle.

Peoples indigenous to different parts of the world turn out to differ genetically in their relative frequencies of loops, whorls, and arches. For instance, Jews, Arabs, southern Italians, and other Mediterranean peoples have lots of whorls, while northern Europeans have many loops and few arches, and Chinese have as many whorls as loops. Nobody has been able to show that these genetic differences are of the slightest adaptive significance. It's not that loops were better for gripping Viking helmets during the long Scandinavian winter, while whorls help you pick olives in t warm Mediterranean sun. After a Swedish fingerprints are like those black Africans, while Jewish fingerprir are like those of Indonesians—despite t gross differences among those peoples climate experienced and in life style.

Instead, each people acquired its ov characteristic fingerprint genes by chanc through genetic drift and the founder e fect, and carried those fingerprints arou during its migrations. That's why the pe ple of Madagascar still have Indonesia like fingerprints, 1,500 years after the emigrated from Indonesia to Madagasca Similarly, the fingerprints of Ashkenaz Jews still resemble those of their ancie Arab and Egyptian neighbors, rather tha those of their recent German neighbor even though these same Jews have by no become thoroughly Germanified in tern of their ABO blood groups. The same co clusion emerges from studies of Rhesu blood groups, haptoglobins, and variou enzymes still thought to serve as neutr markers. In these respects as well, Easter European Jews continue to march wit Arabs and to stand apart from their Eas ern European Gentile "hosts" of the la thousand years.

Thus, judging by neutral markers, th non-Jewish contribution to the Ashke nazic and Sephardic Jewish gene pool ha been low. These groups of Jews may reall be transplanted Semites, not converte Khazars or products of massive interma riage. Whether that is as true of Ethiopian Yemenite, and Indian Jews remains to b resolved. They are the Jews whose diaspo ras took them to especially distinctive en vironments, and who were cut off mos completely from Jews of their Mediter ranean homeland. Somehow, as a resul they became genetically the most distinc tive groups of Jews and the ones that mos resembled their Gentile hosts. That migh reflect conversion, intermarriage, geneti drift during their long isolation, adaptatio by natural selection to their distinctiv new environments—or some still-de bated combination of those effects.

If we accept the predominantly Jewish origin of the Ashkenazic Jews, then thei "Gentilization," as evidenced by thos adaptive markers, must have developed within the roughly twelve centuries sinc they settled northwest Europe, en route t Eastern Europe. Jews thus provide a strik ing example of rapid, recent evolution.

That conclusion may at first seem as tonishing. We hear so often that the Cro Magnons of 30,000 years ago were virtu



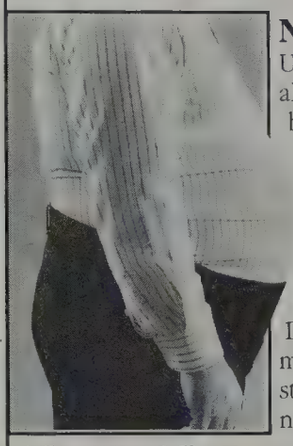
lly identical to modern humans. (How many times have you read that you wouldn't notice a Cro-Magnon if you met one walking along the streets of New York, wearing a modern suit or dress?) We're accustomed to thinking of evolution as operating on a time scale of millions, or hundreds of millions, of years: seven million years to accumulate the differences between humans and chimpanzees; fifty million years to derive big modern horses from little protohorses; and so on. We regularly refer to evolution as a "theory"—as though it were a debatable inference from indirect evidence.

Actually, there is superabundant evidence for animals evolving under our eyes: British moths becoming darker since the Industrial Revolution (industrial melanization), insects evolving DDT resistance since World War II, malaria parasites evolving chloroquine resistance in the last two decades, and new strains of flu virus evolving every few years to infect us. On reflection, it's not the least bit surprising that Ashkenazic Jews of 1993 differ from their Mediterranean ancestors of 1,200 years ago. That's roughly fifty human generations; plenty of time for big changes in gene frequencies to accumulate, even if the average change per generation was only a few percent. Those claims that Cro-Magnons of 30,000 years ago are indistinguishable from us refer only to their skeletons, the sole parts of Cro-Magnons that have survived for us to examine. Many of their nonskeletal parts must have differed greatly from ours. They were unlikely to have had our genetic antimalarials, our gene for digesting milk as adults, our ABO blood group frequencies, and myriad other genetic traits. Even their bones differed from ours, although not enough to attract attention on the streets of New York. For example, their teeth were on the average slightly bigger, and their skulls slightly thicker.

As for the claim that evolution is an unproved theory, that's nonsense. Evolution is a *fact,* established with the same degree of confidence as our "theory" of the round earth, our germ "theory" of disease, and the atomic "theory" of matter. Yes, there is lively debate about the particular evolutionary mechanisms that caused particular changes, but the existence of evolutionary change is not in doubt. Our own bodies provide walking evidence.

Jared Diamond is an evolutionary biologist and professor of physiology at UCLA Medical School.

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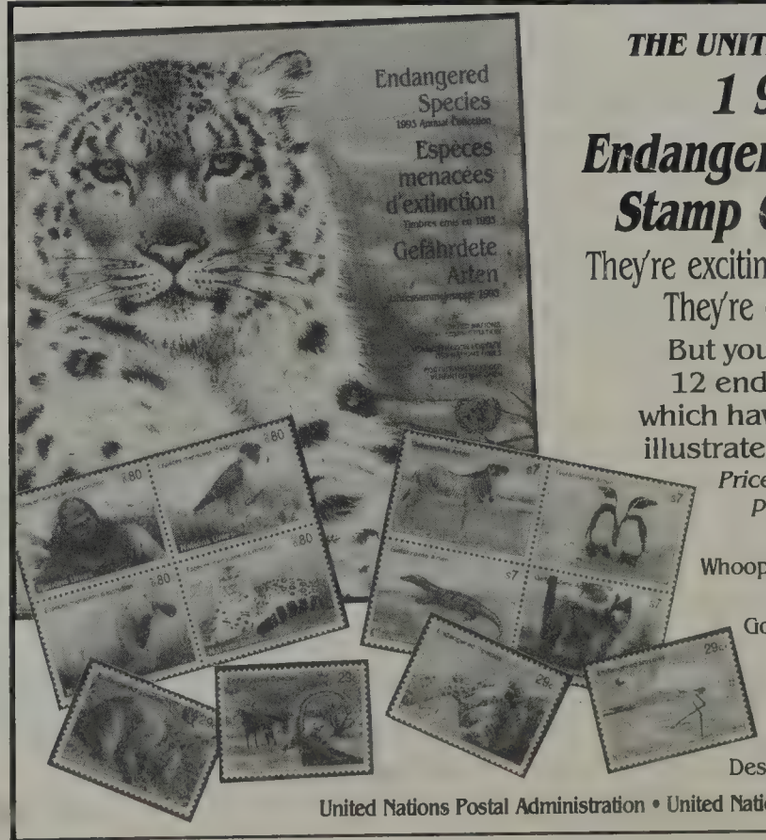
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The Sexual Politics of Classification

Why did male chauvinist Linnaeus choose a female trait to name our class?

by Stephen Jay Gould

William Hayley (1745–1820), poet, biographer, and patron of the arts, owes his little corner of immortality almost entirely to the couplet written by William Blake at the termination of their relationship:

> Thy friendship oft has made my heart to ache:
> Do be my enemy for friendship's sake.

The wealthy Hayley had engaged Blake to engrave figures for his books and had housed the great poet and illustrator in a cottage on his estate near Chichester. But Hayley never understood Blake's idiosyncratic brilliance and threatened to throttle his artistic genius with philanthropic kindness attached to expectations for tamer poems and figures. Calling Hayley "an enemy of my spiritual life while [pretending] to be the friend of my corporeal," Blake penned his couplet about artistic integrity and moved back to London.

At about the same time, another acquaintance of Hayley's was also writing heroic couplets. Consider these lines from 1789 about a lovers' meeting on a mountaintop. The woman reaches the summit first, and her love follows:

> The steepy path her plighted swain pursues,
> and tracks her light step o'er the imprinted dews;
> Delighted Hymen gives his torch to blaze,
> Winds round the crags, and lights the mazy ways;
> Shed o'er their secret vows his influence chaste,
> And decks with roses the admiring waste.

Heroic couplets, with their stilted images and forced rhymes in iambic pentameter, tend to attract ridicule these days (although I, as a great fan of Alexander Pope, do not ally myself with this consensus). The lines of Hayley's friend, quoted above, do seem hard to defend, especially when you realize that he is not talking about human lovers stealing a kiss in solitude before a magnificent view, but about lichens—yes, those patches on rocks representing the complex symbiosis of an alga with a fungus.

Nonetheless, Hayley thought highly of his botanical colleague, for he wrote a poem to introduce his friend's versified descriptions of plant sexuality:

> Thus Nature and thus Science spake
> In Flora's friendly bower;
> While Darwin's glory seemed to wake
> New life in every flower.

Now scarcely a column goes by in this series without some mention of Charles Darwin. Moreover, since my hero wrote many botanical books (mostly late in his life), readers might assume that Hayley is praising the author of natural selection in these lines. But unless Hayley had unusual insight into future events, he cannot be speaking of Charles, who was born on Lincoln's birthday in 1809, twenty years after a different Darwin wrote lyrics for lichens. Who, then, is this earlier Darwin?

To achieve best prospects for a ripe old age, one should choose long-lived parents. Similarly, brilliant forebears provide the best predictors for intellectual success (rich doesn't hurt either). Charles Darwin was certainly fortunate in his choice of ancestors. His father, Robert, was a highly respected and wealthy physician. Even better, his grandfather Erasmus (1731–1802), source of Hayley's praise, was o of England's leading intellectuals—phy cian, scientist, philosopher, and promine member of a movement of progressive i dustrialists and scholars, centered in Bir ingham. Constituting themselves as t "lunar society" to honor their month meetings at the full moon, these men a vocated a variety of liberal reforms in po itics and economics but eventually r afoul of public opinion when the Fren revolution, which they had vigorous supported in its early days, started to su press religion and execute kings. (As parochial footnote for Americans, Da win's good friend and fellow society mem ber the clergyman-chemist Joseph Pries ley watched his house, library, an laboratory go up in smoke when crow rioted in Birmingham on July 14, 179 the second anniversary of the fall of th Bastille. Priestley, supported by his frien John Adams and Thomas Jefferson, eve tually settled in Pennsylvania. But An toine Lavoisier, Priestley's French cou terpart in the discovery of oxygen, fare far worse by feeding the guillotine durin the height of the Reign of Terror.)

William Hayley wrote his puff to intro duce a later edition of *The Loves of th Plants,* a book that Erasmus Darwin fir published in 1789, a happier time, durin the French revolution's auspicious begi nings. Darwin stated that he wrote this ex tended poem on the sexuality of plants fo the most pervasive and conventional o author's reasons: " 'The Loves of th Plants' pays me well, and...I write for pa not for fame." (Darwin was not a dabblin amateur but a well-known and widely rea English poet, however much his chose style and substance provoked a later era

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sure from the history of art. The young Wordsworth wrote of the "dazzling manner of Darwin," although Coleridge stated in 1796: "I absolutely nauseate Darwin's poem," while allowing that Darwin had at least "accumulated and applied all the sonorous and handsome-looking words in our language." Interestingly, Darwin published the first edition of *The Loves of the Plants* anonymously, fearing that the risqué subject might injure his lucrative medical practice.)

Why would anyone write four cantos and 238 pages of heroic couplets about plants, and why would anyone buy such a work in the late eighteenth century? Darwin may have written for money, but he never tired defending his own broadly based philosophy of natural history. We must view *The Loves of the Plants* primarily as a work of advocacy—for its point of view, not its magnificently antiquated poetry, has given this book a substantial place in the history of science. Darwin's footnote to his couplets on lichens provides insight into his larger purposes (Darwin accompanies each verse with a prosaic explanation of his grand metaphors in small type):

> Lichen...Clandestine marriage. This plant is the first that vegetates on naked rocks, covering them with a kind of tapestry, and draws its nourishment perhaps chiefly from the air; after it perishes, earth enough is left for other mosses to root themselves; and after some ages a soil is produced sufficient for the growth of more succulent and large vegetables. In this manner perhaps the whole earth has been gradually covered with vegetation, after it was raised out of the primeval ocean by subterraneous fires.

As scholars say so often (although the message never really sinks in because people seem to crave clean points of origin and heroic initiators), Charles Darwin did not invent the concept of evolution. Instead, he took this most common of nineteenth-century biological heterodoxies, gathered more copious and persuasive evidence than ever before, and discovered a plausible mechanism of change in natural selection. Charles's own grandfather Erasmus ranks among the most prominent (and vocal) of his precursors. (Charles never knew his grandfather personally, for Erasmus died in 1802, but remained a strong presence in the Darwin household, and Charles read and admired his writings.)

Erasmus's thoroughly historical and evolutionary view of nature—not rare during the Enlightenment, but by no means orthodox either—shines forth in his commentary on lichens, which presents, in its remarkable last sentence, an epitome of the earth's progressive history: from bare land raised from the ocean by internal fires to formation of soil through the erosive action of lichens to growth of larger and more complex plants upon the substrate made by these lowly organisms. We need both the footnote, and some knowledge of Erasmus's evolutionary view, to make sense of his last line: "And decks with roses the admiring waste"—a reference to this later growth of higher plants upon the soil produced by lichens.

But advocacy of evolution provides only a subsidiary theme to *The Loves of the Plants*. Darwin wrote his long poem for a different theoretical purpose, and the key lies in the first two words of his footnote on lichens: "clandestine marriage." Darwin composed *The Loves of the Plants* as a popular presentation of Linnaeus's so-called sexual system for botanical taxonomy, using the age-old literary devices of pleasant form (rhymed couplets) and accessible imagery (the metaphor of personification). In the first paragraph of his "advertisement," placed at the very beginning of his volume, Darwin explained:

> The general design of the following sheets is to enlist Imagination under the banner of Science; and to lead her votaries from the looser analogies, which dress out the imagery of poetry, to the stricter ones, which form the ratiocination of philosophy. While their particular design is to induce the ingenious to cultivate the knowledge of Botany, by introducing them to the vestibule of that delightful science, and recommending to their attention the immortal works of the celebrated Swedish Naturalist, Linnaeus.

Linnaeus's sexual system for botanical classification, first proposed in the 1730s, became a focal point for popular education in the natural sciences—an important cultural theme in the late eighteenth century, as the Enlightenment swept Western Europe. Not everyone cared for Linnaeus's decision to base the taxonomy of plants on numbers and arrangements of male and female organs in flowers. Predictably, some conservatives detested an explicit sexual basis for anything, fearing a collapse of public morals (a fragile thing indeed if subject to such easy undermining by a mere counting of stamens and pistils!). Prof. Johann Siegesbeck of Saint Petersburg decreed that God would never have based his natural arrangements on such a "shameful whoredom," and Linnaeus responded by naming a small and ugly weed *Siegesbeckia* in his honor. Linnaeus himself had severe doubts about t sexual system because he recognized artificial basis in often grouping unrelat plants into the same category. But L naeus never found a natural system, a he continued to use his sexual classific tion *faute de mieux*.

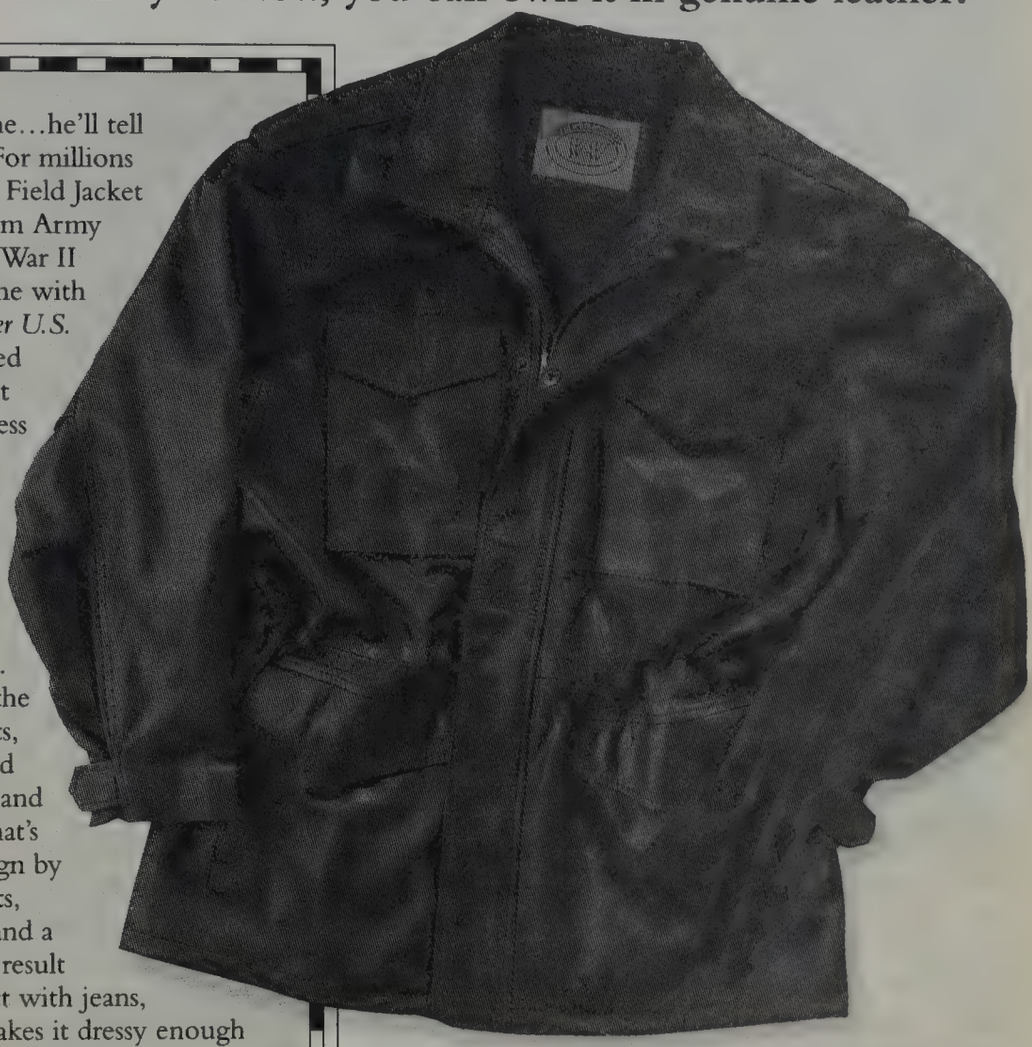
Linnaeus's sexual system found greatest advantage in utility—easy learn and easy to practice. Proponents popular education therefore becar strong advocates. As a leading liber thinker, committed to increasing Britai commercial power through the spread scientific knowledge among the publ Erasmus Darwin looked upon Linnaeu sexual system with particular favor. Da win established the Botanical Society Lichfield (his home town in Staffordshir especially to sponsor the translation in English of two Linnaean books on botar cal taxonomy—the *Species plantarum* a the *Genera plantarum* (these were du accomplished and prominently advertis in *The Loves of the Plants*).

The sexual system of Linnaeus is n based on anything so salacious as the m chanics of observed fertilization, b rather upon the dry anatomy of numbe and arrangements of stamens and pistil the male (pollen-bearing) and fema (ovary and stigma-bearing) parts of flo ers. (Very little was known about pla sexuality in Linnaeus's time; even the exi tence of separate sexual parts and fertiliz tion remained controversial.) Linnaeu original hierarchical system utilized fo categories—classes, orders, genera, a species in descending levels. (Modern ta onomy maintains the same structure, b introduces more categories—kingdo and phylum on top, and family betwee order and genus, for example.) The key t Linneaus's sexual system lies in his pr mary division of plants into twenty-fo classes, based almost entirely on numbe and arrangements of male organs.

The first thirteen classes include he maphrodite flowers (containing both ma and female parts) and base divisions o the number of stamens (most flowers hav one pistil, but several stamens of roughl equal length). The first ten—named Mo nandria, Diandria, Triandria, and so on, o one male, two males, three, males, and s on—simply refer to the number of sta mens. Class 10, Decandria, thus contain flowers with ten stamens. Class 11, Dode candria, has twelve; Class 12, Isosandria has twenty; while Class 13, Polyandria, c many males, includes all higher numbe from twenty to one hundred. The next tw

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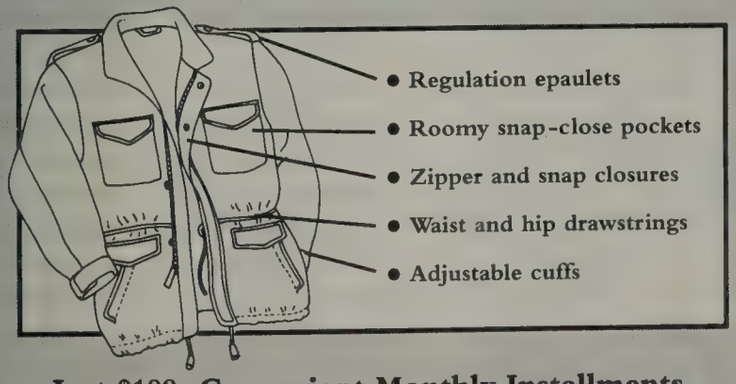


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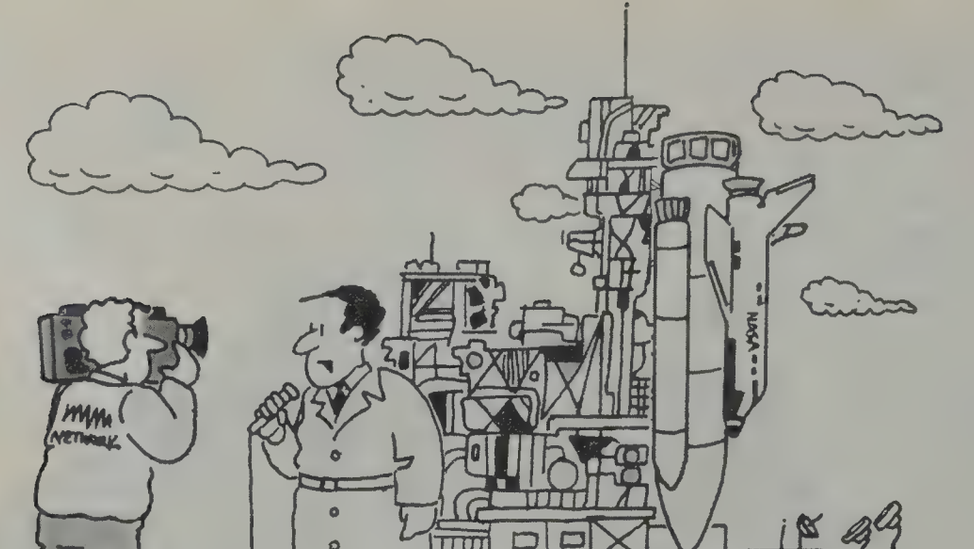
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classes, called "powers" by Linnaeus, recognize flowers with stamens of two distinct sizes. Class 14, Didynamia, or two powers, has four stamens, two short and two tall; while Class 15, Tetradynamia, or four powers, has six stamens, two short and four tall. The next five classes, 16 through 20, honor the mode and degree of adhesion among stamens, not their number. Classes 16 through 18 refer to different arrangements of joining by filaments, or "stems" of the stamens—Monadelphia (one brotherhood) for one group, Diadelphia (two brotherhoods) for two groups, and Polydelphia for three or more groups. Class 19, Syngenesia, or confederate males, includes flowers with stamens joined by their anthers, or top parts. Class 20, with the loaded name of Gynandria, or feminine males, contains flowers with stamens attached to the pistil.

Three of the last four classes accommodate plants with separate male and female flowers. For classes 21 and 22, Linnaeus coined two words still prominently in use by botanists—Monoecia (one house) for separate male and female flowers on the same plant and Dioecia (two houses) for male and female flowers on separate plants. Class 23, Polygamia, includes plants with both hermaphrodite and separate-sex flowers. Finally, Linnaeus named his last class Cryptogamia, or clandestine marriage, for plants with sexual parts that he could not observe. Botanists still use "cryptogam" as an informal term for plants that reproduce by spores or gametes rather than seeds—a heterogenous and nongenealogical group that includes ferns, mosses, and algae. We can now finally understand Darwin's initial description of lichens as "clandestine marriage" and his poetic image of males sneaking up on females. He is referring to their status at the base of Linnaeus's list, in Class 24.

Metaphor is a dangerous, if ineluctable, device. We use images and analogies to foster understanding of complex and unfamiliar subjects, but we run the risk of falsely infusing nature with the baggage of our parochial prejudices or idiosyncratic social arrangements. The situation can become truly insidious, even perversely so (in the literal rather than pejorative sense) when we impose a human institution upon nature by false metaphor—and then try to justify the social phenomenon as an inevitable reflection of nature's dictates!

Arguments of this sort have long been prominent in the sensitive areas of sexual and racial politics, where dominating groups tend to seek biological rationales for their truly transient and unjustifiable social status. To choose a perhaps silly, but not really trivial, example, all engineers on a ship that once served as my home for nine months referred to plugs as "he" and sockets as "she"—thus reinforcing the notion that males penetrate and females accept. (I shall never join the language police, nor lobby for changes in this case, b I do regard the examples as instructive.)

Or, to choose a more recent and co crete case, some biologists have identifie (although, to be fair, certainly not d fended) human rape as natural becaus brutally forced copulation in some bird including mallard ducks, has long bee called "rape" in the technical literatur But use of the human term for birds is pu metaphor, not a statement backed by ev dence for common causality. We have r reason for linking two such different ph nomena—one (in humans) primaril about social power; the other (in bird clearly about reproduction—by the sam name merely because they share a superf cial resemblance in who does what t whom. Yet by falsely describing an inhe ited behavior of birds with an old name fo a deviant human action, we subtly sugge that true rape—our own kind—might be natural behavior with Darwinian adva tages to certain people as well.

Since sex is so powerful and pervasiv in our lives, the error of reading our ow socially conditioned ways into nature be comes most apparent when we us metaphors based on human sexuality, es pecially when we borrow from th charged (and usually sexist) realm o power based on gender. In one sense, Lin naeus's sexual system might be deeme relatively free of such human interference since he mostly just counts stamens an pistils and records their lengths.

But a closer look reveals that Linnaeus' botanical macrocosm becomes, throug his sexual system of classification, a bi ased reflection of the human social micro cosm. Most notably, he follows the olde convention of sexism by regarding mal differences as primary and female varia tion as secondary—for Linnaeus based hi highest division into twenty-four classe on male characters, and his subsequen finer division into many more orders o female traits! (These points have bee forcefully made in two excellent article that helped me greatly in preparing thi essay: Janet Browne, "Botany for Gentle men: Erasmus Darwin and *The Loves o the Plants*," *Isis*, 1989, and Lond Schiebinger, "The Private Life of Plants Sexual Politics in Carl Linnaeus and Eras mus Darwin," *Science and Sensibility Gender and Scientific Enquiry 1780-1945*, edited by M. Benjamin, Oxfor University Press, 1991.)

Moreover, as my earlier epitome of hi sexual system shows, Linnaeus infused hi classification with human terms and con

cepts. Conjoined stamens are "brotherhoods," and single-sex flowers live in either one or two "houses." Such metaphorical terminology pervades Linnaeus's writing. He refers to fertilization as an act of marriage and speaks of stamens and pistils as husbands and wives. Flower petals are bridal beds, and infertile stamens become eunuchs, presumably guarding the wife (pistil) for other fertile stamens (husbands). Schiebinger cites a fascinating passage from an essay that Linnaeus wrote in 1729:

> The flowers' leaves...serve as bridal beds which the Creator has so gloriously arranged, adorned with such noble bed curtains, and perfumed with so many soft scents that the bridegroom with his bride might there celebrate their nuptials with so much the greater solemnity.

But Linnaeus, at least in his public persona, was a social conservative and something of a prude on sexual issues. He did not allow his four daughters to study French, for fear that they might thus learn the liberal standards of that land. When his wife sent one daughter to school, Linnaeus promptly withdrew her, declaring such education for women "nonsensical." He also refused the queen of Sweden's offer to receive one of his daughters at court, for fear that such an environment might promote moral laxity (he may well have been right). We should therefore not be surprised that Linnaeus's sexual metaphors for plants tended to be drab (however lyrically expressed) and rather strictly within the married state.

In the so very different persona of Erasmus Darwin, however, sexual imagery for plants reached its apogee. Darwin was liberal in politics, probably a genuine atheist in religion, and remarkably broad-minded in his views on sexual behavior. He had twelve children in two happy marriages, and lived openly with a third woman in between, fathering two additional daughters who then lived in harmony with him and his second wife. He favored schooling for women and wrote a work entitled *Plan for the Conduct of Female Education* when his two illegitimate daughters set up a seminary for girls. He was no egalitarian (but then who was, among wealthy eighteenth-century British males?). He wanted to educate intelligent women to become better companions for their husbands, not to prepare them for professions.

In short, Erasmus Darwin viewed sex as a natural part of a healthy and rational world order—and these attitudes provided a much broader base for metaphors be-

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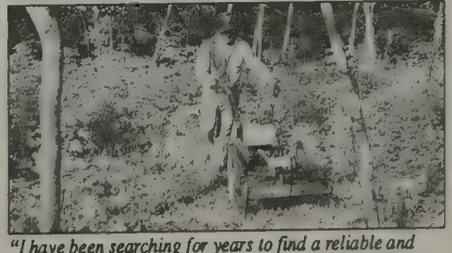
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yond legitimate marriage when he chose images to describe the sexuality of plants. Moreover, in deciding upon the consistent and fully explicit device of treating stamens as male persons and pistils as female, he developed a degree of human imagery for plants that neither Linnaeus, nor any other prominent botanist writing for the public, ever essayed—and all in flowery heroic couplets to boot!

Darwin's liberality served this metaphorical tradition well, for the images just didn't work in Linnaeus's restricted world of legal marriages. After all, most flowers have several stamens for a single pistil—meaning many husbands for one wife if the metaphor be carried to its logical conclusion. We are therefore stuck with the rarely acknowledged phenomenon of polyandry and not with the more conventional malfeasance immortalized in William James's amazing epitome of human relationships:

> Higgamus hoggamus, woman's monogamous
> Hoggamus higgamus, men are polygamous.

A contemporary critic rightly identified this weakness, in rejecting Linnaeus's images "because the great concourse of husbands to one wife is so unsuitable to the laws and manners of our people." But Erasmus Darwin, not so restricted, could talk of numerous suitors, beaus, and swains for one young female beauty—so his more varied personifications violated neither law nor custom.

The Loves of the Plants is no libertine debauchery, but more a tale of pleasantly courting rustics and gentlefolk in Arcady. Still, Darwin does describe some remarkable social situations in metaphor—and his impositions of human affairs upon plants becomes an amusing example of a common practice that serves as the focus of this essay and that becomes decidedly unfunny, even pernicious, in a variety of historical examples from the annals of racism and sexism (including the case of mallard "rape" described earlier).

Darwin, for example, does not always avoid the nuptial terminology of Linnaeus's earlier uses, and he does acknowledge the consequent, and unconventional, polyandry. He writes of *Iris,* in the class of Triandria, or three males:

> The freckled *Iris* owns a fiercer flame,
> And three unjealous husbands wed the dame.

He laments the fate of plants in the class Monoecia, for males and females dwell in different beds (flowers) within the same house (plant), and must therefore be estranged in some way:

> *Cupressus* dark disdains his dusky bride,
> One dome contains them, but two beds divide.

But truly separated lovers in the class Dioecia (male and female flowers on different plants) win his admiration for their tenacity in achieving a treacherous meeting across great distances. The naked pistil grows up and calls to her beaus:

> Each wanton beauty, tricked in all her grace,
> Shakes the bright dew-drops from her blushing face;
> In gay undress displays her rival charms,
> and calls her wondering lovers to her arms.

As one might expect, stamens in the class Gynandria, or feminine males (stamens attached to pistils) do not fare well and are branded as both effete and subjugated:

> Gigantic Nymph! the fair *Kleinhovia* reigns,
> The grace and terror of Orixa's plains…
> With playful violence displays her charms,
> And bears her trembling lovers in her arms.

Inevitably, I suppose, Darwin depicts males of the classes Didynamia and Tetradynamia (two and four powers, with one group of stamens shorter than the other) as belonging to disparate social classes:

> Two knights before thy fragrant altar bend,
> Adored *Melissa*! and two squires attend.

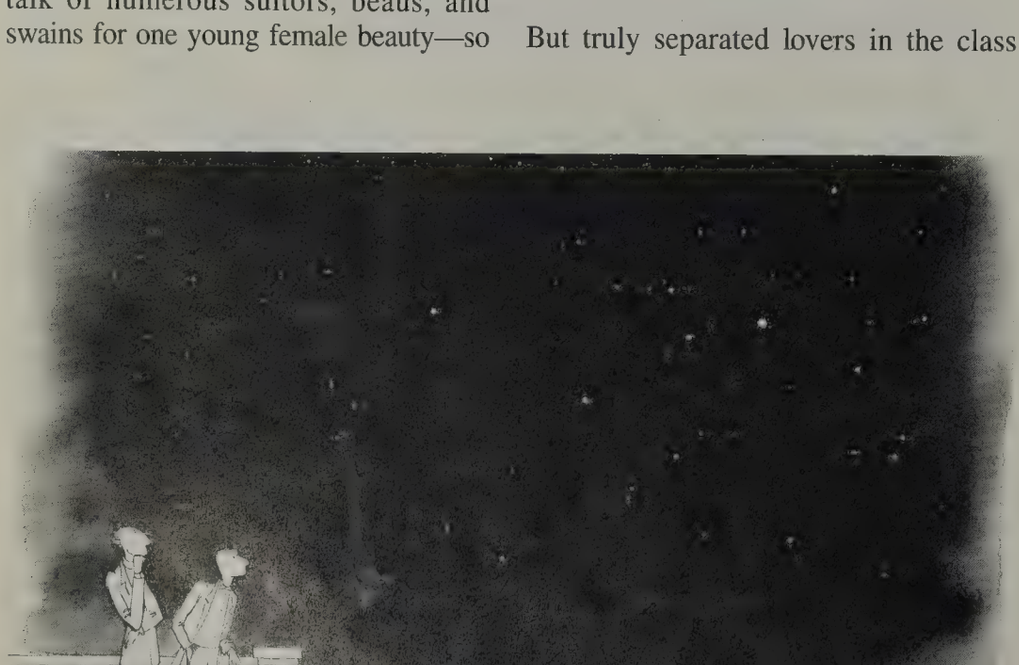
And for Tetradynamia, with four bosses and two underlings:

> Pleased round the Fair four rival Lords ascend
> The shaggy steeps, two menial youths attend.

But for all his toleration of variety and multiplicity, Darwin does draw the line at one point. Hybrid matings between genera, yielding no fertile seed, do violate all moral propriety:

> *Caryo*'s sweet smile *Dianthus* proud admires,
> And gazing burns with unallowed desires;
> With sighs and sorrows her compassion moves,
> And wins the damsel to illicit loves.

As a final example, Janet Browne, in her excellent article cited earlier, notes that Darwin, perhaps unconsciously, grants different status to pistils (females) depending upon how many stamens grow in the



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same flower (or, in the chosen metaphorical image, how many males she has under her control). Flowers of the class Monandria (one stamen and one pistil) are united in monogamous and connubial bliss: He writes of *Canna,* or Indian reed, uncomfortably transported from the tropics to cold Britain, but able to survive the chill by the warmth of committed love:

> First the tall *Canna* lifts his curlèd brow
> Erect to heaven, and plights his nuptial vow;
> The virtuous pair, in milder regions born,
> Dread the rude blast of Autumn's icy morn;
> Round the chill fair he folds his crimson vest,
> And clasps the timorous beauty to his breast.

Darwin also treats "lowly" plants of the last class, Cryptogamia, as similarly virtuous, for at least they hide whatever they do. He even shows compassion in acknowledging that the short and the ugly can also enjoy sexual pleasure (more than Disney would later grant to his seven dwarfs). He writes of underground truffles:

> Deep, in wide caverns and their shadowy aisles,
> Daughter of Earth, the chaste *Truffelia* smiles;
> On silvery beds, of soft asbestos wove,
> Meets her gnome-husband, and avows her love.

At an intermediary number of four to six stamens, Darwin invokes a variety of images about pursuit, lust, and coyness. Males are depicted as vigorously courting swains and beaus; females may be flirtatious or tough, but they are not easily won:

> *Meadia*'s soft chains five suppliant beaux confess,
> And hand in hand the laughing belle address;
> Alike to all, she bows with wanton air,
> Rolls her dark eye, and waves her golden hair.

A tougher sister exerts more control:

> With charms despotic fair *Chondrilla* reigns
> O'er the soft hearts of five fraternal swains;
> If sighs the changeful nymph, alike they mourn;
> And, if she smiles, with rival raptures burn.

But females accompanied by large numbers of males (ten or more stamens to one pistil) are invariably depicted either as truly dismissive or as fully regal:

> Sweet blooms *Genista* in the myrtle shade,
> And ten fond brothers woo the haughty maid.

With twenty males at her beck and call, the pistil must be a powerful goddess:

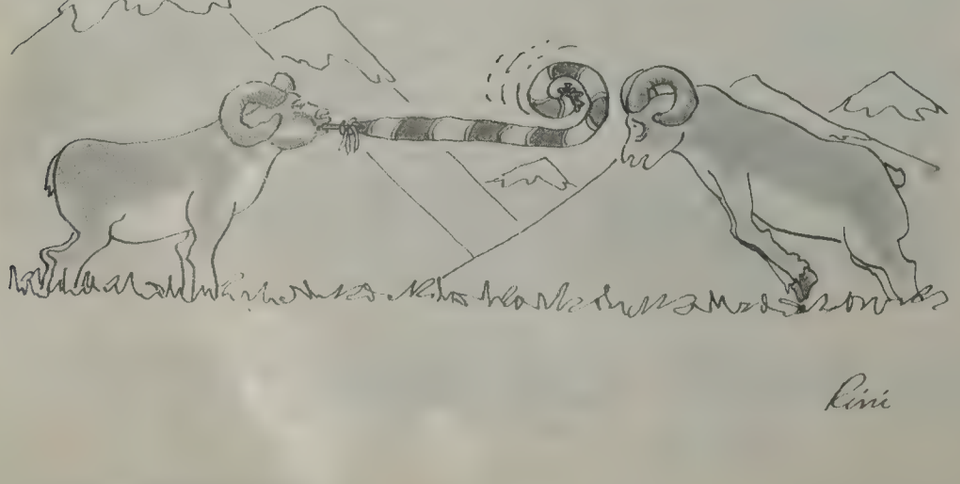
> While twenty Priests the gorgeous shrine surround
> Cinctured with ephods, and with garlands crowned
> Contending hosts and trembling nations wait
> The firm immutable behests of Fate.

We may laugh at these particular Darwinian reveries, but the underlying theme of our tendency to impose a human social scheme upon supposedly objective nature, especially in the charged domain of se and gender, teaches us something impo tant about the cultural construction knowledge. I therefore close with anothe Linnaean example from the other end our conventional taxonomic ladder. knew that Linnaeus had invented the ter Mammalia for our vertebrate class in h *Systema naturae* of 1758, but I thoug that he had simply promoted an old ve nacular word to a new technical meanin However, in a brilliant article, Lond Schiebinger shows that Linnaeus truly i vented the word—and that no languag had ever before referred to the group warm-blooded, hair-sporting, live-bearin vertebrates as mammals ("Why Mamma are Called Mammals: Gender Politics i Eighteenth-Century Natural History," *Th American Historical Review,* 1993).

All previous systems had treated an named our relatives differently. Aristot established a vertebrate group calle Quadrupedia, with a primary subdivisio into Oviparia (scaly and egg laying, i cluding reptiles and some amphibians and Viviparia (hairy and live bearing, thu including most mammals, but also exclud ing such creatures as bats, whales, an most importantly, humans). By Linnaeus time, our group had a better definition, bu no recognized name. John Ray for ex ample, the greatest of Linnaeus's prede cessors, had suggested Pilosa, meanin hairy, as a way of annexing obviously re lated animals that did not exhibit Aristo tle's defining feature of four legs.

So why did Linnaeus choose a nev name, and why, particularly, did he choos such a peculiar term as Mammalia, refer ring (obviously) to the female breast? W must grasp the extreme unconventionalit of Linnaeus's decision. Most generally and for the usual sexist reasons, we tend t personify active phenomena as male—an organisms judged most complex shoul certainly fall under this convention. (I contemporary English, we still invariabl refer to an unsexed animal as "he," as i "isn't he cute," or "look at 'im go.") If Lin naeus had been an explicit egalitarian, ou to sink a bad habit by example, he migh have chosen Mammalia for this overt po litical reason. But Linnaeus, as we hav seen, was a social conservative and a con ventional sexist. More particularly, zoolo gists have long translated this general cul tural convention into technical practice by treating male organisms as the canonica icon for any species.

Why, then did Linnaeus choose a fe male trait to define the highest group, ap



rently adding insult to male injury by lecting a feature that males also possess, ut in a rudimentary and useless state? chiebinger argues cogently that Linnaeus ade his decision for an ideological rea- on—one very distant from any notion of xual equality. Linnaeus had been deeply ngaged in a different, and equally impor- nt, battle, this time (or so most of us ould judge today) on the right side: his mpaign to classify humans *into* nature ith other animals, at a time when many aturalists still insisted on a separate uman kingdom for beings with a soul and reated in God's image.

Propagandists have always recognized hat an adroit choice of name can convey reat power of persuasion. Nature has al- most invariably been personified as fe- ale, in a cultural and linguistic tradition ating at least to Chaucer (see the *Oxford nglish Dictionary*'s entry of "Nature"). If ne wishes to gain some rhetorical advan- ge in a struggle to place humans within ature, then choose a female feature to de- ne our larger group, thereby emphasizing ur closeness to Mother Earth and her ther animate productions. Interestingly, n the same work that defined our larger roup as within nature, Linnaeus sought to eparate us as a species for our mental rowess—and here he chose a male desig- ation, *Homo sapiens* (although the Latin *omo* may be taken more generally in the ld sense of "humankind," while *vir* is, nore specifically, a male person—from vhich we obtain, and for sexist reasons, ne notions of virtue and virility).

We are therefore mammals, rather than airy or eary beings, as yet another legacy f pervasive sexual politics. (I am not oing justice to the complexity and sub- tety of Schiebinger's full argument. She resents many other sources of evidence, ncluding Linnaeus's active involvement n a movement against wet-nursing—ac- omplished largely by trying to persuade vealthy women that they should not view leparture from nature as a virtue, but hould get in touch with our common her- tage by suckling their own babies.)

If we are surrounded by such a miasma f social prejudice at the heart of what we egard as objective knowledge, what hope lo we have for understanding a natural vorld that is, in so many respects, truly ex- ernal to us? I have no simple answer, but great thinkers offer us tidbits that can be ntegrated into a solution. Since William Blake chose to preserve his integrity gainst the siren song of Hayley's patron- ge, he provides several insights in his idiosyncratic, and often oracular, verses. Consider two thoughts from his *Songs of Innocence* (published in the same year as Darwin's *Loves of the Plants*). Nature and social life are not entirely commingled, and much injustice is of our own making:

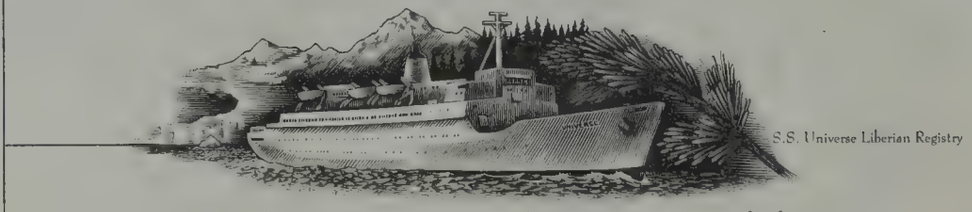
When my mother died I was very
young,
And my father sold me while yet my
tongue
Could scarcely cry 'weep! 'weep!
'weep! 'weep!
So your chimneys I sweep, and in soot
I sleep.

And lest we continue our old attempts to blame our worst traits upon our biological heritage, we should also remember that what we call human nature embodies much potential for good amid the tendencies we might choose to brand as evil:

For Mercy has a human heart,
Pity, a human face,
And love, the human form divine,
And Peace, the human dress.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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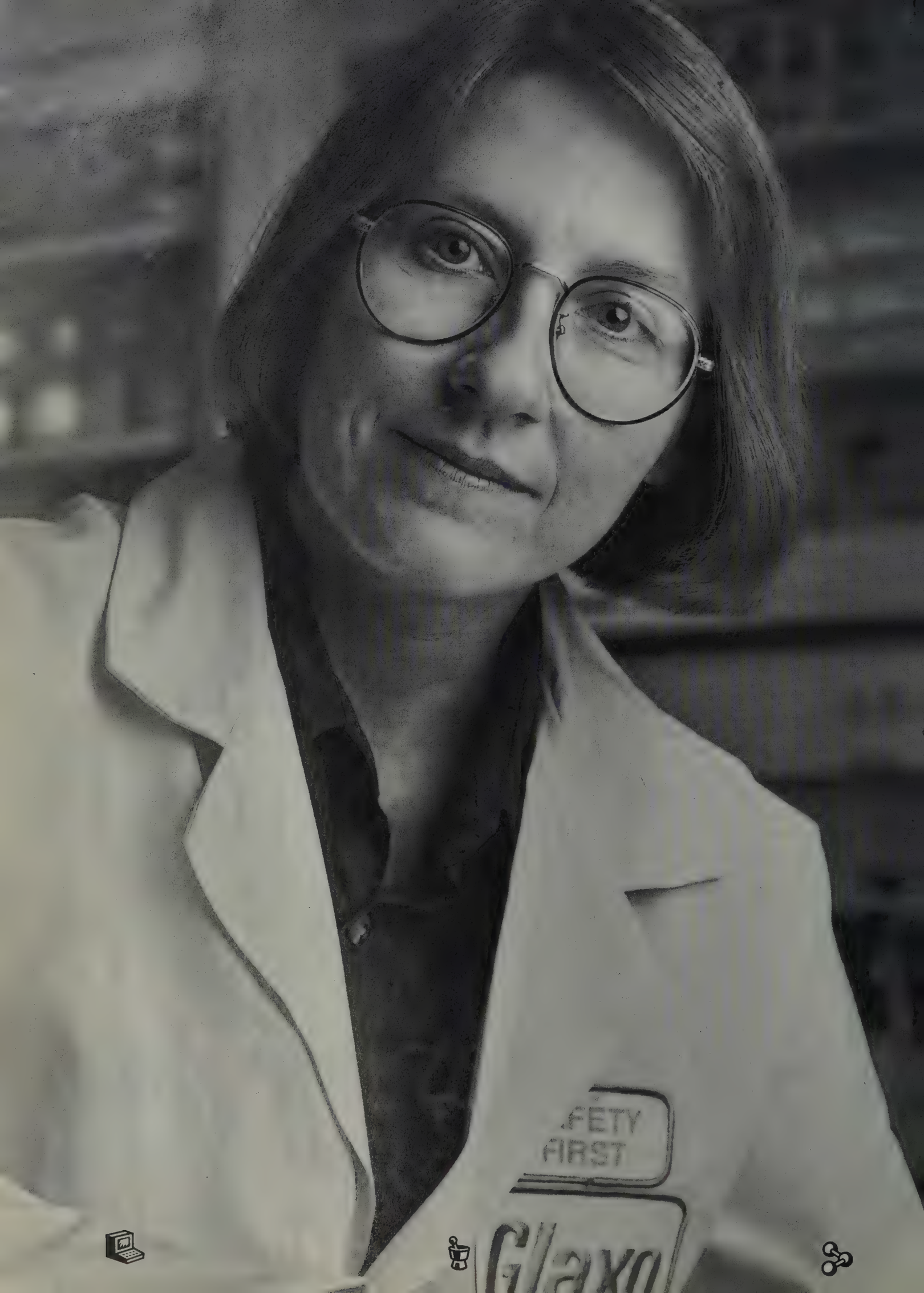
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In the Belly of the Bird

Its digestive system may be long or short, fast or slow, depending on diet

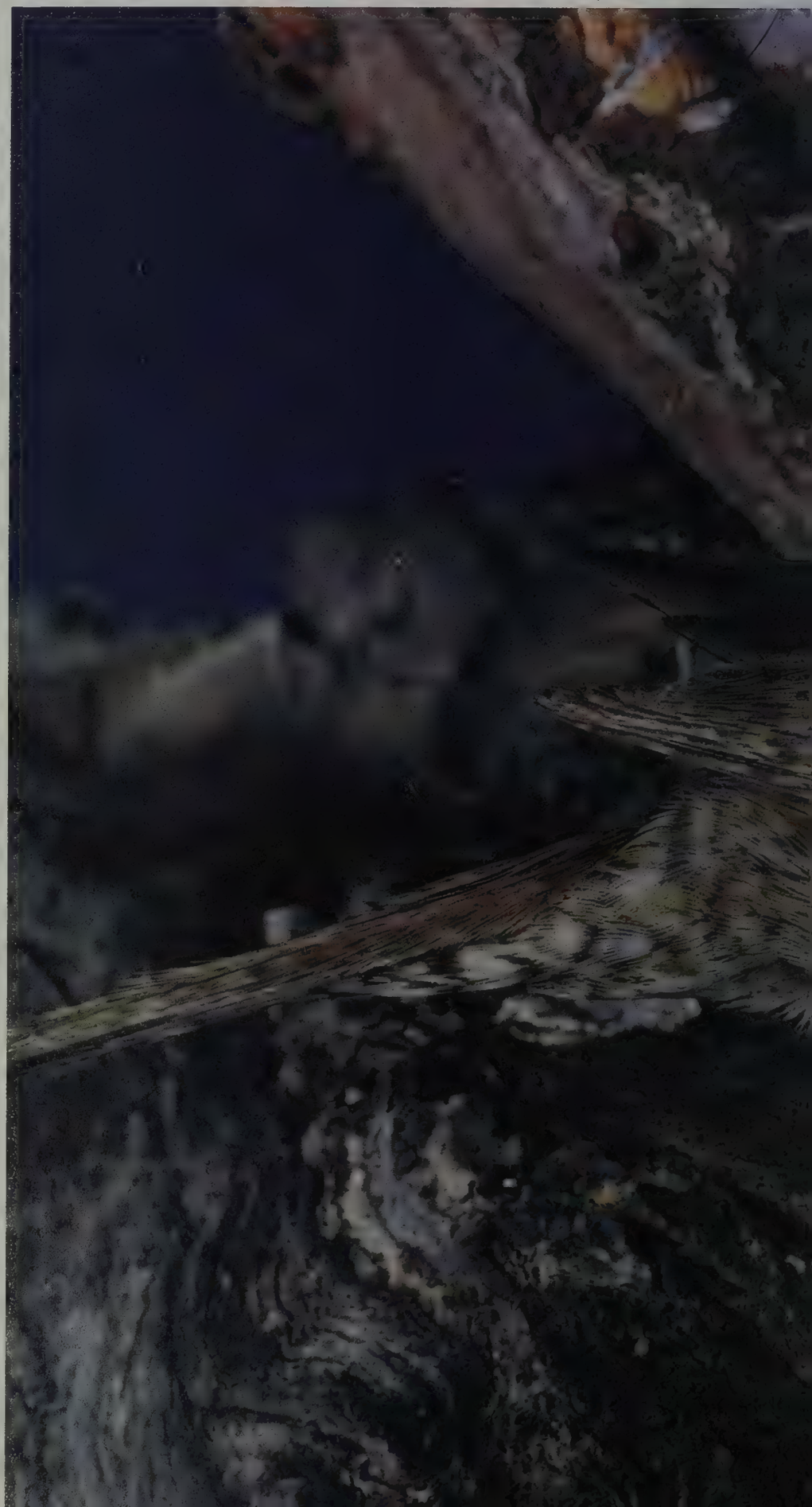
by William H. Karasov

Every fall, millions of migrating birds put on a spectacle for the residents of the Northern Hemisphere. Their capacity for long-distance flight and their navigational skills are familiar sources of wonder. Also impressive, but less conspicuous, are the large amounts of food these birds must eat to fuel their long journeys. Even birds that stay closer to home must often increase their food consumption to cope with the cooler temperatures of fall and winter. Yet at this time of year, many birds spend long periods perched quietly on branches, apparently doing nothing. Why are they loafing, rather than out beating the bushes for food?

To answer this question, we must peer beneath the birds' beautiful feathers for a peek at their digestive systems. At first, eating more sounds like a fairly straightforward proposition. The bird collects as much as it can, and then the digestive system takes over: the crop or esophagus stores the food, the stomach and gizzard begin to break it down, the intestine completes the breakdown and absorption. We often assume that food availability, and hence the rate of food collection, are the limiting factors. But some bird studies are upsetting this simple view and adding a new element: in some instances food is plentiful and what is probably limiting is the rate at which the bird can digest food.

My studies of house wrens, conducted with my colleague Cheryl Dykstra, illustrate how even insect-eating birds sometimes can collect food much faster than they can digest it. House wrens are small (10-gram) brown birds that feed entirely on the grasshoppers, beetles, caterpillars, bugs, and spiders they collect from the ground, trees, and shrubs. Observed in the wild feeding their nestlings, these active birds found prey and returned to the nest with it as fast as once every three minutes. We estimated that they were capable of collecting 44 grams of arthropods a day, twice as much as our laboratory wrens could ever eat and digest in a single day.

And yet there are times of the year when birds' digestive systems are clearly able to take advantage of abundant food.



A house wren plucks an arthropod from tree bark. From their thin beaks to their digestive tracts, wrens are adapted for catching and processing fat- and protein-rich insects, caterpillars, and spiders.
Lois and George Cox; Bruce Coleman, Inc.





Gregory K. Scott

Cedar waxwings eat mostly fruit year round. Perched on a mountain ash, a waxwing takes advantage of ripe summer berries, left. In winter, the pulpy remains of a withered fruit, below, provide the bird with sugars, which it digests easily.

Jan L. Wassink



During migratory stopovers, some perching birds gain weight at the rate of 10 percent of their body weight per day. And some shorebirds, such as sanderlings, increase their weight 40 percent over two to three weeks. How do they do it?

In the eastern United States, house wrens generally spend the winter in Virginia, Tennessee, Arkansas, and points south, where the average minimum daily temperature ranges from 30° to 50° F. To maintain their body temperature (104° F) in this relatively cold environment, wrens eat much more food each day than they do at summertime temperatures, which are generally at least 20° F warmer. Wrens kept experimentally at 39° F or lower and given free access to insects, for example, ate about as often as they did at 75° F — every twelve minutes — but their meals were 50 percent larger, so that over the course of a day, they ate twice as many insects. The birds also digested their food more efficiently; that is, they absorbed more of the energy they consumed.

To accomplish this digestive feat, the wrens use a trick that appears to be fairly common among birds: they simply grow more intestine, as much as 22 percent more. In this way, they are able to take in more food per meal and still retain it in the digestive chamber for as long as they do when eating less per day with a smaller gut. The larger intestine also provides more surface area for the chemical breakdown and absorption of food.

Wrens aren't the only birds to exhibit changes in gut size. Several other species, both migratory and nonmigratory, such as the rufous-sided towhee, rock ptarmigan, and spruce grouse, also have longer guts at times of the year when they eat more food. Humans can grow more intestine, too. When surgeons remove portions of a diseased intestine, the remainder compensates by increasing its surface area. And the tremendous eating capacity of a nursing woman is probably due to changes in her gut. During lactation, other mammals increase their feeding rate two to three times; to keep up, the intestine increases in length and mass.

The mechanisms for these changes aren't completely understood but, in laboratory animals at least, clearly involve growth of more cells in the intestine, especially the absorptive mucosal cells lining the intestinal tube, which are replaced every two or three days. The signal for this growth may be the amount of nutrients delivered to the gut. Once food intake dies down again, fewer mucosal cells are produced and intestinal mass decreases.

Wrens prove to have a second physiological feature that matches up with their natural diet: they are less effective at absorbing sugar than most other birds we have studied. Like mammals and other vertebrates, birds have special mechanisms, much like enzymes but called transporters, for absorbing sugar across the intestinal wall. Judging by their maximum rates of sugar absorption, the wrens appeared to have only a fifth to an eighth as many of these sugar transporters as some of their avian neighbors in the forest, such as the American robin and the cedar waxwing.

This difference is probably related to diet. Wrens, strictly insectivorous year round, eat foods that contain primarily protein and fat and that generally lack sugar. Just as evolution by natural selection has resulted in a match between a bird's diet and many of its external traits, such as bill shape, it might also be expected to result in a match between diet and digestive physiology. A survey of

Dwight R. Kuh

A young American robin captures an earthworm, right. Flexible in their diet, robins also savor berries, below, particularly in fall and winter, but are less adept at digesting sugars than are the frugivorous cedar waxwings.

Mark. F. Wallner



birds with different dietary habits supports this idea: the more carbohydrate in the diet, the greater the intestine's ability to absorb sugar.

Not all birds, however, are as fixed in their diet as is the house wren. Some are almost entirely insectivorous during the breeding season but eat large amounts of fruit either during migration or once they reach their wintering grounds. Fruit figures prominently in the winter diets of the catbird, the tree swallow, at least four warblers (the chestnut-sided, bay-breasted, yellow-rumped, and pine), and the American robin and other thrushes. The robin, for instance, increases its fruit intake from a low of about 10 percent of the total diet in the spring breeding season to as much as 90 percent in the fall and winter. (The switch in diet is due partly to changes in availability of fruit relative to arthropods, but there is also some evidence that, with the changing seasons, the robins' preference for fruit increases to some extent, even when arthropods and worms are still available.)

Fruit is a much bulkier food than insects, worms, and spiders. Considering the sometimes dilute solution of nutrients found in the pulp, not to mention indigestible seeds, fruit has relatively few digestible calories per food item (both sugary grapes and high-fat dogwood berries, for example, yield only 40 percent of the energy contained in a similar-sized insect). Thus, the birds must eat more to meet their daily caloric requirement. Furthermore, not all fruits are the same. Most contain less fat, far less protein, and more sugar than insects do, but some have a fairly high fat content. Birds switching from arthropods to fruit, then, must manage not only to take in more food but to handle a range of nutrients.

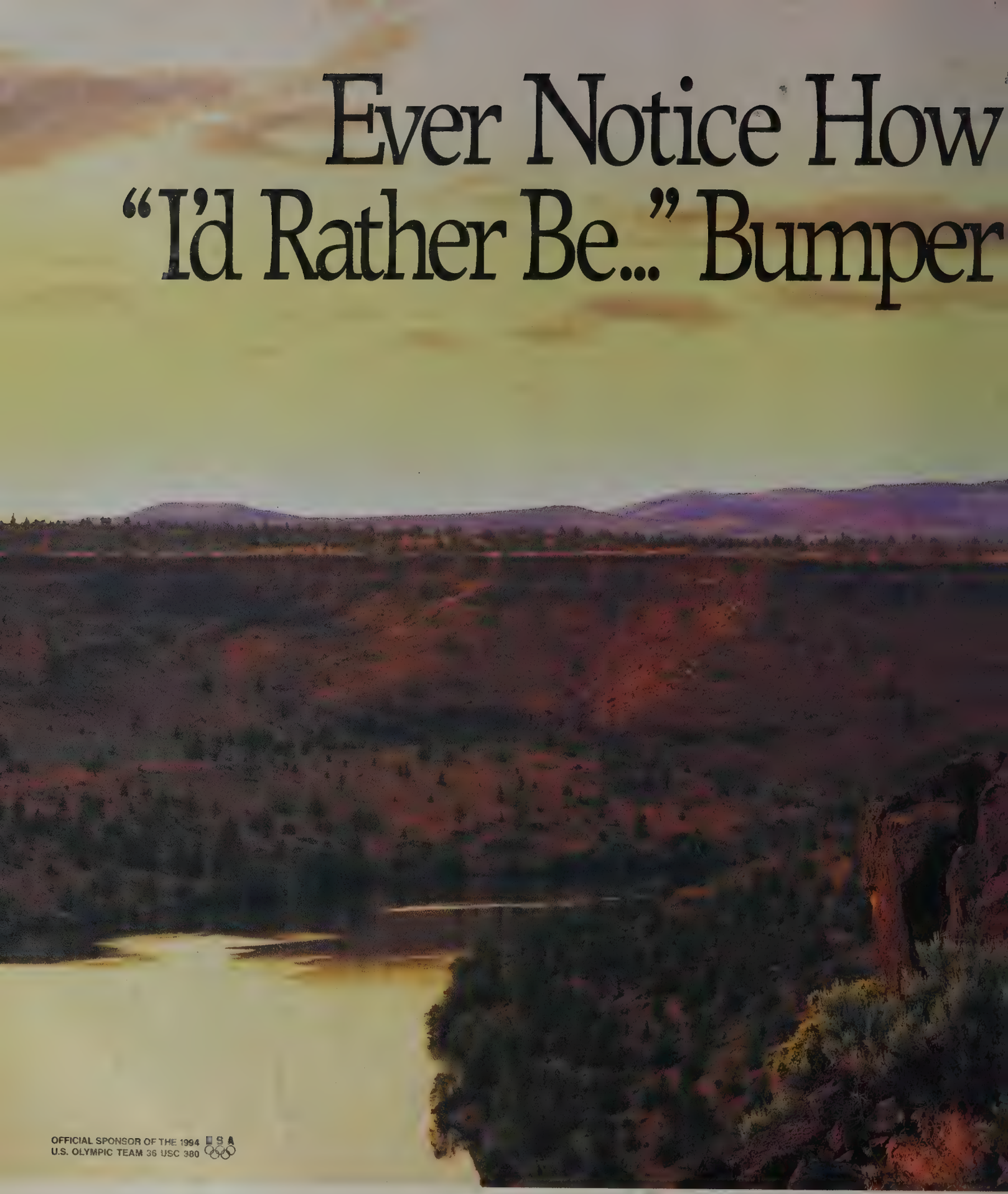
To find out what sorts of digestive changes, if any, permit birds to switch from arthropods to fruit, my colleagues Doug Levey and Carlos Martinez del Rio and I decided to compare the seasonally frugivorous robin with the insectivorous house wren and with the cedar waxwing, which is primarily frugivorous all year. We did experiments in the fall and found that in most matters of the gut, robins proved to be inflexibly designed, more like insectivores than frugivores. Like wrens, they digested and absorbed almost three-fourths of the energy in insects, thanks to high rates of intestinal amino acid absorption. Also like the wren, they had relatively low rates of sugar absorption, even when feeding on fruit. Unlike waxwings, robins lack sucrose, the enzyme that splits the complex sugar sucrose into the simple sugars glucose and fructose, and thus they are less able to digest the many fruits, such as cherries and blueberries, which contain some sucrose. This in itself may not be a major problem in nature because the sugars of most wild fruits appear to be simple ones, such as glucose and fructose, but robins proved less efficient than waxwings at digesting these sugars, too. Poor absorption of a smaller range of sugars is probably part of the reason robins must always supplement their fruit diet with earthworms, beetles, and caterpillars.

Robins do exhibit one important digestive feature that enables them to rely on fruits as heavily as they do in fall and winter. Like all frugivores that have been studied, robins process fruit rapidly. Large seeds are separated from pulp in the stomach and regurgitated the way they came in. The bird then rapidly digests the pulp and defecates the remaining skin and small seeds. When switched from insects to fruits in the laboratory, robins speed up their digestive processing about two times, excreting the remains of a fruit meal about forty minutes after ingesting it and thus making room for the next meal. Digesting so fast is somewhat wasteful, as some perfectly digestible nutrients are excreted along with the bulky, indigestible material. But for fruit-eating birds, this is generally not a problem, as there are usually more berries or cherries to be had nearby.

We don't yet know whether seasonal frugivores like the robin can increase their gut length as the wren does. But recent studies of European garden warblers, which are also seasonal frugivores, have shown that these birds increase their digestive efficiency during migration, suggesting that they have flexible guts like the wren's. The digestive adjustments are important; robins and other fruit-eating birds that might appear to be taking their ease perched on a branch may actually be working hard, digesting just as fast as they possibly can. □



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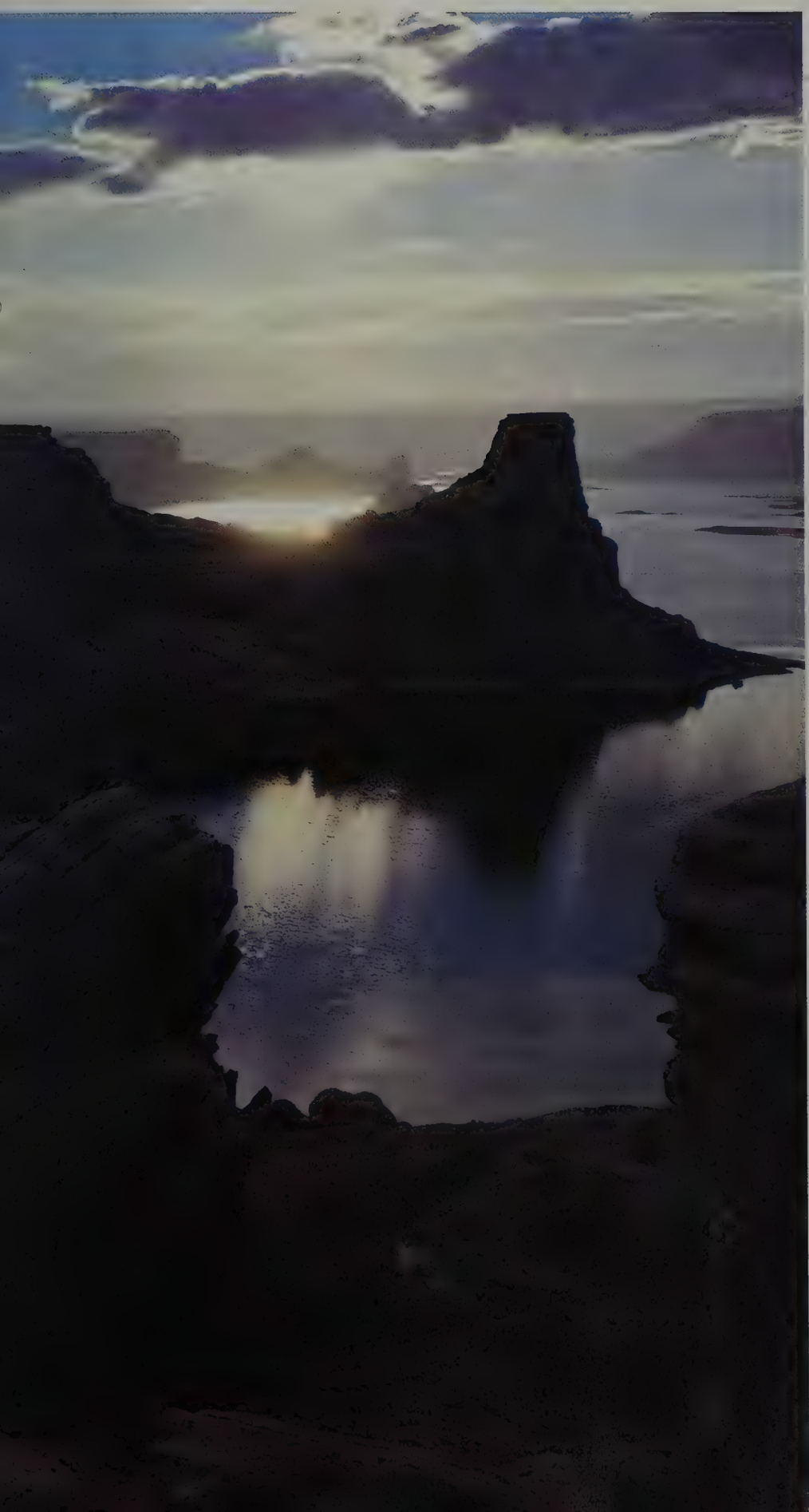
Lake Powell, created in the mid-1960s by Glen Canyon Dam's impoundment of the Colorado River on the Utah–Arizona border, covers more than 250 square miles of land, including hundreds of sites once inhabited by the Anasazi Indians.
David Muench



Damming the Past

Are reservoirs destroying our archeological heritage? Scuba divers give us an answer

by Daniel J. Lenihan



The movie light I hold in one hand plays over a graffiti-covered wall in the dark, concrete building. A scrawl in balloon letters, "The Lord Cometh," reminds me of spray-can wisdom I have seen on a hundred subway cars. I float slowly through the flooded hallway, walking on the index and middle finger of my free hand. Tiny clouds of silt puff up as I leave my odd paw prints. Another ghostly form, that of my diving partner, rises effortlessly toward the ceiling. He prepares to snap a picture of the illuminated words.

The building was probably a foundry. The Lord may have been here, but he's gone now. We linger for a second photo, then we too move on. Gently, silently but for the sound of our exhaled breaths splashing on the ceiling, we glide through a series of doorways devoid of doors and propel ourselves through a glassless window. On emerging, we are in the light of day, subdued by the twenty feet of water between us and the air above.

What does it take to cover sixty square miles of New Mexico desert with water? Sometimes, an act of God, but in this case it was the Bureau of Reclamation. In 1911, Burec cameth and made rise the waters of the Rio Grande to create the Elephant Butte Reservoir and Recreation Area. The Southwest is full of these improvements on nature. They harness indolent rivers for electrical power, allow people to live in flood plains, and convert desert scrub into profitable farmland. Regaining the surface, I am reminded that they also insure the popularity of the outboard engine. Protective of the student divers under my supervision, I make obscene gestures at boaters who come too close to our diver warning flags.

I have visited many of these watery worlds. From 1975 to 1980, I led a National Park Service study of major water-impoundment areas in the United States, mainly in the arid Southwest. Other researchers were charged with assessing loss of habitat and scenic values. My task was to determine if the federal money allocated for salvaging archeological sites was being prudently spent.

An 1873 photograph shows Clear Creek, a tributary of the Colorada River, winding its way through a valley south of Leadville, Colorado, on the eastern slope of the Rockies.
William Henry Jackson, "Moraines on Clear Creek," 1873; U.S. Geological Survey



The dozens of large reservoirs built by the Army Corps of Engineers, Bureau of Reclamation, Tennessee Valley Authority, and others throughout the country impact river valleys, usually the locus of past human activity. The scope of this phenomenon is hard to convey. The combined surface area of just two of the artificial lakes on the Colorado River, lakes Mead and Powell, for example, is more than 500 square miles, or about half the size of Rhode Island. Sizable portions of these two lakes are deep enough to cover the Washington Monument. Beneath them now lie some 2,000 known sites of the Anasazi—the ancient ones—ranging from the ruins of pueblos to scatterings of stone tools. The sites identified in surveys before the valleys were flooded probably represent only a fraction of those actually present. Apart from the value archeologists attach to these remains, one can only imagine what living Indian peoples must feel when they see their heritage, including sacred sites and ancient landscapes, obliterated.

Even as the dams were being built, the American preservation community managed to impress upon Congress that archeological remains are irreplaceable. This sometimes elusive point was easiest to establish with politicians from regions where the loss of impressive ruins would be noticed by their constituents. One piece of legislation in the early 1970s authorized the spending of up to one percent of the entire cost of a new reservoir on salvage archeology. Large-scale excavations of the most dramatic sites in the deepest parts of the about-to-be lakes seemed the remedy of choice.

The result, however, was warehouses full of artifacts needing expensive curating, from sites dug for the wrong reasons. A reaction to this process was taking shape in the archeological profession about the time our study began, culminating in the formation of the American Society for Conservation Archeology. These archeologists argued for more focused use of available human and monetary resources—in essence, elegance of research design instead of energetic shoveling. Terms such as "partial-site excavation," "minimal impact archeology," and "problem-oriented research designs" started to replace "dig we must."

Were history and prehistory destroyed when covered by impounded river waters? Or were they preserved forever in an underwater data bank for future generations? Environmental impact statements authoritatively supported these two contradictory positions. With public funds going toward some very comprehensive and expensive archeological projects, federal reservoir managers wanted some definitive answers fast. The National Park Service was given the ball, and I, a diving instructor with a degree in anthropology, got to be quarterback. I moved to Santa Fe, where at the behest of Calvin R. Cummings, regional archeologist for the service's Southwest region, I assembled a team.

With more than a little dismay we realized that we had to define what was of archeological value before we could decide whether or not it was being destroyed.

Clear Creek Reservoir now fills the same valley. A local project dammed Clear Creek to supply water to the city of Pueblo and its environs.
Mark Klett and JoAnn Verburg; Rephotographic Survey



Is the stuff of archeology made up of only artifacts and bones and their relative locations? What about the texture and color of the soil they are found in—how does flooding affect such archeological clues? What of the soil chemistry, which helps to establish where humans performed different daily activities? What of the subtle properties of materials dated through arcane laboratory tricks? Heady fare for a handful of archeologists just out of graduate school, selected for the job largely because we could dive.

This foundry dive is a training exercise for a group of sport divers wishing to refine their underwater recording skills. As I struggle to remove my wet suit, however, I dredge up memories of reservoir dives past. My mind's eye takes me momentarily from the nearby shore of the placid Rio Grande to the mighty Colorado. It gives one pause to stand on the brink of Glen Canyon Dam and look down at the Colorado River on one side and Lake Powell on the other. A raging river, a piece of raw wilderness, has been molded into a huge pond. At the bottom of the sixty-story concrete megalith, a reconstituted Colorado seems to shrug off the insult and strive to regain its personality. By the time it hits the Grand Canyon, it has become a serious river once more. Farther downstream it is dammed again to form Lake Mead, then Lake Mohave, and yet again to become Lake Havasu.

Hundreds of speedboats zooming in what seem to be long lanes of traffic give Lake Havasu the appearance of an aqueous turnpike. To cap the impression of some sort of surreal theme park, an entrepreneurial genius has placed the reconstituted London Bridge across a side channel of the impounded Colorado River. Moved stone by stone from the Thames, the bridge now stands as a monument to the general level of intelligence involved in our use of human energy and natural resources in the great American Southwest.

Below Lake Mead, released through the turbines of Hoover Dam, the Colorado rages through a narrow, steep canyon for several miles. For scuba divers, this is a challenging stretch. At Ringbolt Rapids the current drags divers down into a hole almost seventy feet deep before disgorging them back to the twenty-foot depth. Here, in the shallower reaches below the rapids, we tried to document the remains of an old river boat (such boats would winch themselves upriver using iron bolts set in the canyon walls). One of our group would try to take a photograph while holding on to the wreck with one hand, but if he relaxed his grip even slightly, the current would sweep him away, leaving behind only a swirl of sand and silt. And if he glanced back upstream, his mask would be ripped off. We eventually decided that a "preliminary evaluation" was sufficient, declared victory, and headed for more convenient sites to document.

The presence of historic shipwrecks in the desert is always cause for wonder. A few miles below Glen Canyon Dam, the *Charles H. Spencer* lies near Lee's Ferry, a popular point for rafters to begin their run through the Grand Canyon. Near the ruins of the old mining camp, the craft lies in

shallow water with most of its lower hull well preserved. At most water levels, the smooth, metal boiler is partly exposed, and Navajos fish from the perch it offers. Prefabricated in San Francisco, the *Spencer* was assembled at Lee's Ferry to carry coal to a gold mine. After the craft was launched more than a thousand miles from the ocean, its owners discovered it took more coal to fight the river than the vessel could carry as cargo. The craft was left to rot on the riverbank—a long-term proposition in this part of the world.

Newly impounded waters hold special surprises. I recall the hull of our small aluminum boat scraping over the tips of branches above Cochiti Dam, as Cochiti Lake filled just west of Sante Fe. These were the tops of ponderosa pines, their roots still embedded in the drowned soil



Toni Carrell; National Park Service

Nicholas Devore III; Photographers Aspen

The Wahweap Marina, left, at the entrance to Arizona's Lake Powell Recreation Area, draws nearly one million visitors annually. Increased tourism puts pressure on fragile environments that were once almost inaccessible. Below, left: A paddle-wheel hub from the steamboat Charles H. Spencer *lies submerged in the Colorado River near Lee's Ferry, Arizona. Below: In Glen Canyon, an archeologist measures pictographs that were later submerged.*

National Park Service



ixty feet below us—New Mexico's high lesert country converted into an evergreen swamp. The Anasazi pueblos, which we had found on our foot survey through this valley years before, would know a strange requiem. While their descendants struggle o maintain an identity, selling their traditional wares on the plaza in Santa Fe, the Anasazi lie buried in earthen house floors, sleeping with the fishes.

Hiking along the ridgetops above Cochiti Dam, I have rested on smooth white logs hundreds of yards above the river. These convenient seats are driftwood, piled there when melts from heavy snowpacks in the Rockies raised the waters to levels unthinkable before impoundment.

During droughts in California's Folsom Reservoir, nature temporarily overrules the dam builders, as rivers fall to their original levels. Here, prehistoric house floors compacted from years of trampling resist the erosion of the receding waters better than the surrounding soils can. The curious result is that once-buried archeological treasures are left pedestaled above the adjacent terrain. Stumps of oak trees stand beside them on their tap roots. Raccoons, nature's opportunists, have done their own excavating in the hardened house floors, placing snail shells and potsherds in neat piles outside their burrows. One suspects they are less interested in scientific analysis than in extracting the mollusks that took up residence in the house floors during inundation, but their precise digging technique would put some archeologists to shame.

Underwater in Texas, I have flutter-kicked through old ranch houses, cut my way through barbed-wire fences, trailed old railroad tracks into the depths, and followed asphalt highways (still feeling some compulsion to keep to the right of the yellow line). In some places I have even seen old dams that have been covered by the waters backed up by new dams. These reinforced concrete monsters that gobble up river valleys devour their own with equal indifference.

Several tense, cold winter days spent searching for a drowned diver in the submerged powerhouse of a dam near the Mexican border will stay with me always. A hundred feet below the surface, my colleague Larry Murphy and I entered through glassless windows much more forbidding than the ones in the Elephant Butte foundry and felt our way cautiously through murky water. Our tanks scraped against hazardous wires and steel bars hanging from the ceiling. Blinded by disturbed sediment that even our powerful lights couldn't penetrate, we felt our way down a flight of stairs, ran our hands over commodes, and searched restroom stalls. With equal caution we made our way back out before our double tanks emptied of their precious air.

We found the young man's body a day later, wedged in a corner between a glass partition and the electrical switch cage. Larry and I felt especially compelled to remove a fellow diver from this alien environment. Muttering words of encouragement to the lifeless form, we maneuvered him through the many obstacles to the surface.

The official conclusions of our National Reservoir Inundation Study, while voluminous, can be boiled down to a few general observations. The most surprising is that one of the lowest impact zones is in the bottom of a lake, particularly if it has

Lowell Georgia; Photo Researchers, Inc.

The creation of a dam and reservoir along the Snake River forced the removal of a church, below, and other buildings in American Falls, Idaho, between 1925 and 1927. Right: One of the greatest of the concrete megaliths built to control a river system, Hoover Dam impounds Lake Mead at Nevada's Arizona border.
Bureau of Reclamation



been flooded quickly. Most of what has archeological value is preserved intact, except for soil chemistry, which loses its analytical use after inundation. Access, of course, is compromised, but the findings are reassuring, at least if the goal is to bank sites for future research.

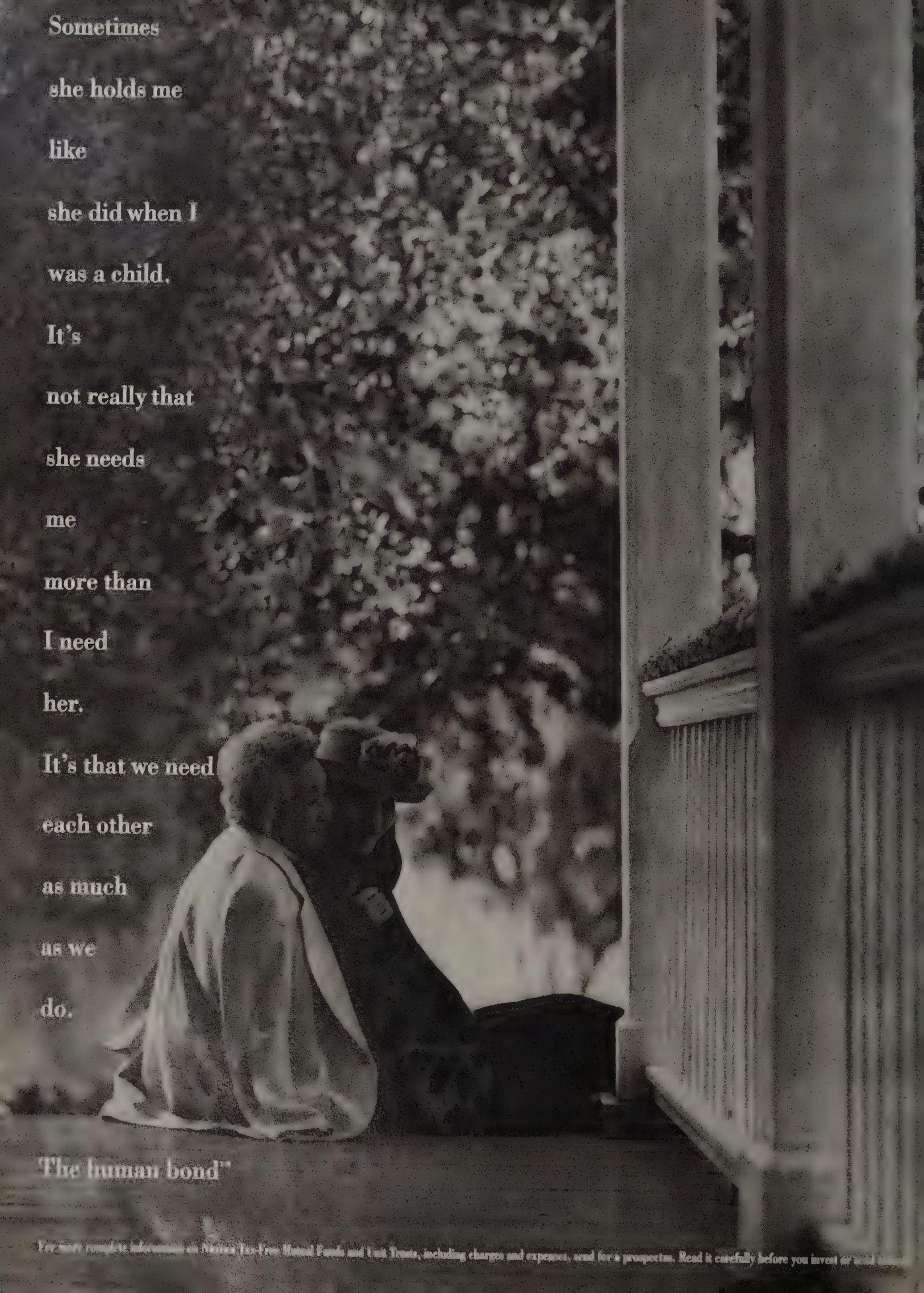
The places worst hit turn out to be the zones where the water level varies up and down, subjecting sites to alternate wet and dry cycles. Little of archeological value survives that sort of treatment. In addition, this is where park goers have their greatest impact. As reservoir levels fluctuate seasonally or over the years, campers follow the beach line, parking their RVs side by side. At Roosevelt Lake in Arizona, for example, stones that marked the ancient house outlines of Hohokam and later Salado peoples for hundreds of years are piled helter-skelter by unknowing tourists to form campfire pits. Even areas outside the maximum flood pool are highly affected, as sites formerly exposed only to occasional visits of Native Americans and backpackers become available to anyone with a bass boat and a sixpack.

Our inundation project also taught us something about American values. Underlying the whole program was the premise that reservoirs were going to be built, archeological sites or endangered snail-darters notwithstanding. Society had already made its fundamental choices; we were providing answers that would improve the efforts to mitigate the impact.

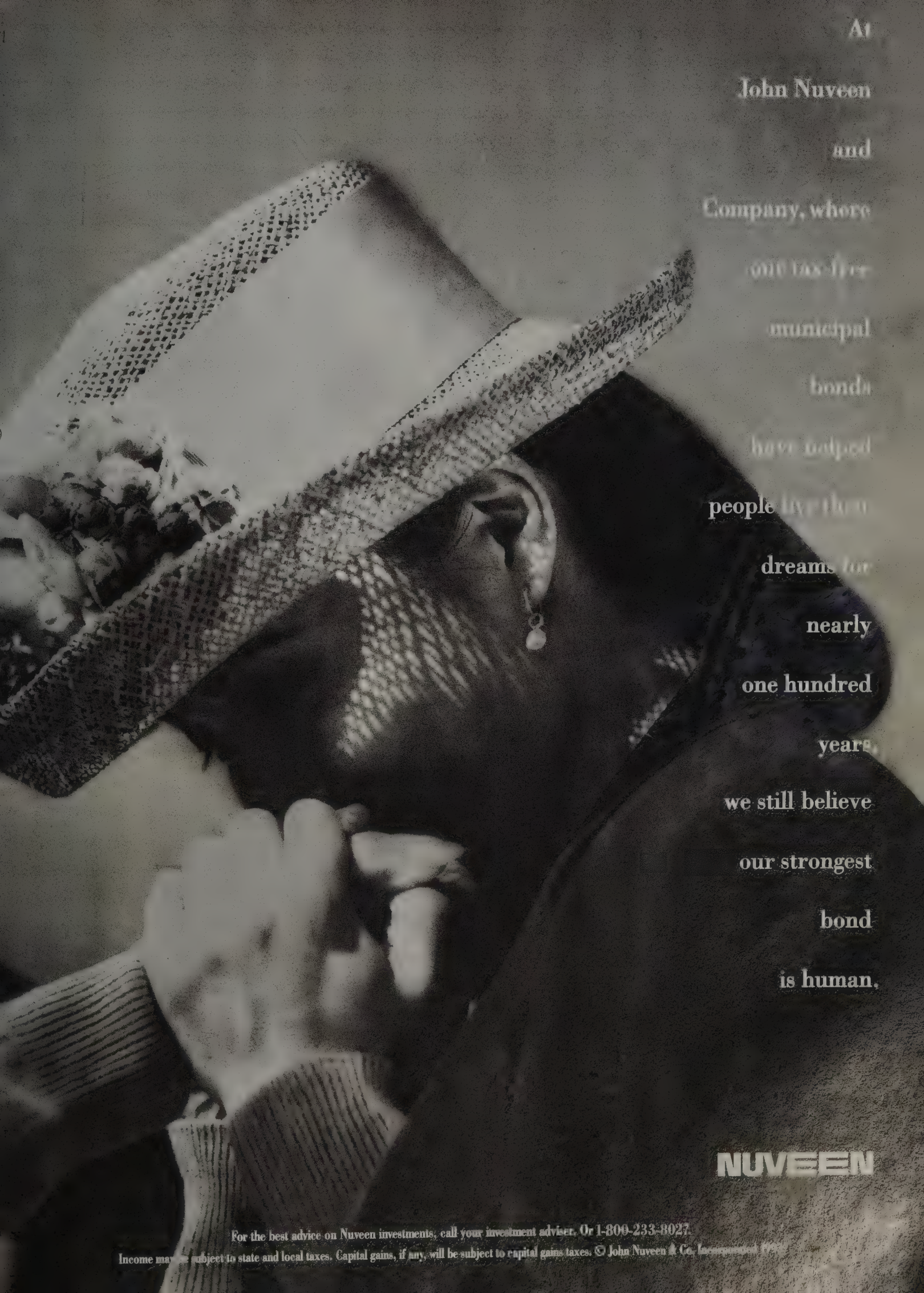
Many reservoirs are beautiful places, although those who love wild rivers may find that hard to swallow. Some people, like the late writer and "eco-warrior" Edward Abbey, have such an intense hatred for dams that they would take satisfaction in seeing them blown up. The heroes of Abbey's *Monkey Wrench Gang* attempt just that, to the vicarious delight of many readers. They could just as well take solace, however, in contemplating the fragility of human-made structures. The ghosts of drowned rivers stir restlessly beneath the placid waters of reservoirs. In the eye-blink of a few thousand years, they will sweep away the concrete and earthen plugs that hamper their quest for the sea.

As I cram the last of the dive gear into our van at Elephant Butte, one of our students approaches me to ask a parting question. She points across the lake at the white line that runs along the steep shoreline just above the present water level—the bathtub ring common to many water impoundments. "What is that anyway?" she wants to know. I tell her it's blue-green algae bonded with calcium carbonate, and if she'd like a closer look, she can glance down at her feet, because she is standing in it. Like many of the things that affect us most, it isn't noticeable until we're removed enough to gain perspective. □





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Tattooed images of America dominate the chest of a convict. The epaulet identifies him as an authority in the hierarchy of inmates, and the eyes mean "I see everything."

Telltale Tattoos in Russian Prisons

In iconographic argot, convicts advertise their history and status on their skin

Text and photographs by Arkady G. Bronnikov

No one has ever counted the number of prisoners with body tattoos in the Commonwealth of Independent States, as the loose association of eleven of the former Soviet Republics is known. The Corrective Labor Administration remains silent on the issue because to admit that 70 to 98 percent of the prison population flout prohibitions against tattoos would be an admission of how badly the system is functioning.

Since the introduction of glasnost, however, the press has published some stunning figures; from the mid-1960s to the 1980s, thirty-five million people were incarcerated. Few other nations in the world have had such a large prison population, and according to the most conservative estimates, twenty-eight to thirty million of the Russian inmates were tattooed.

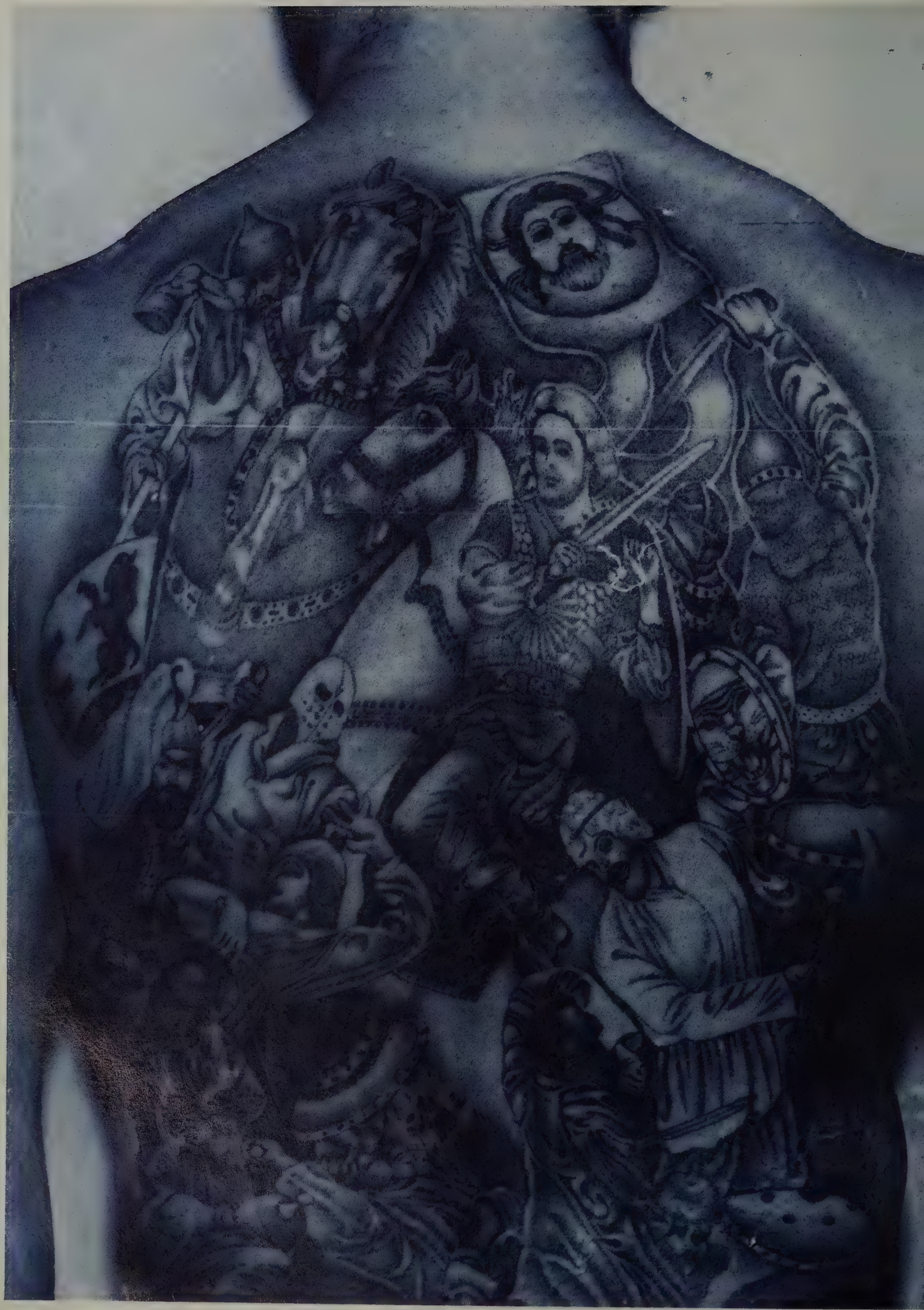
Who are these people? What are their motives for going through the acute pain of getting their bodies covered in tattoos? A criminologist by training, I first started studying tattoos thirty years ago as a means of identifying the corpses of criminals. Very soon I began to suspect that tattoos matched crimes in some way.

Over the years, I visited correctional facilities and and labor camps in the regions of Perm, Yekaterinburg, Chelyabinsk, Kirov, and Sakhalin, and in the autonomous republics of Udmurt, Mari, Tatar, and Komi, where I interviewed and photographed tattooed prisoners. They posed willingly for the camera and spoke with pride about their tattoos. My collection now numbers more than 20,000 photographs, including 1,000 of women.

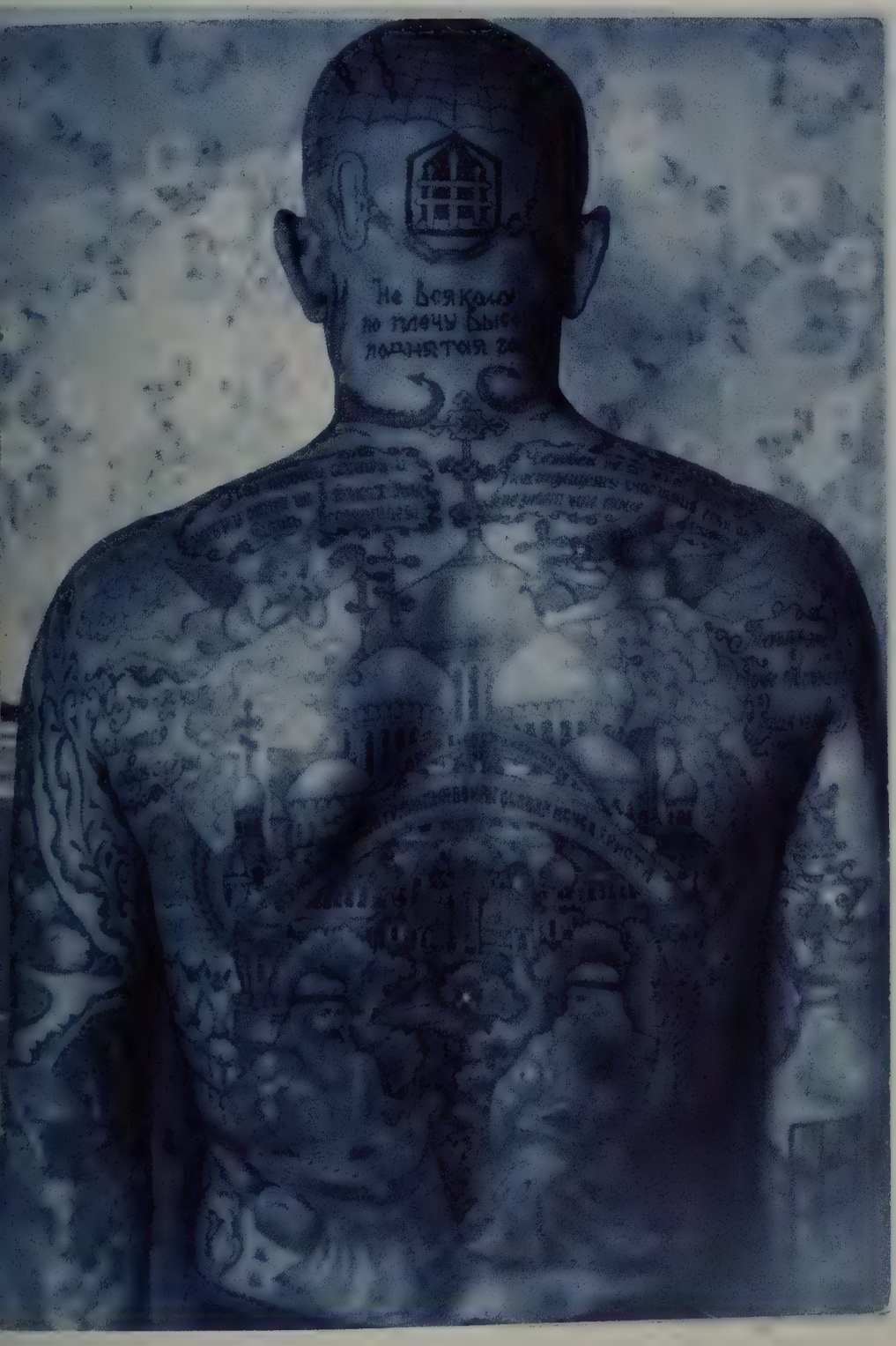
Tattooing methods in prisons are primitive and painful. The convict often makes the tattoo himself, and the process can take several years to complete. A single small figure, for example, can be created in four to six hours of uninterrupted work. The instrument of choice is a reconstructed electric shaver to which prisoners add needles and an ampule with liquid dye. Scorched rubber that has been mixed with urine is used for dye. Dubious sanitation creates serious health complications, including gangrene and tetanus, but the most common problem is lymphadenitis, an inflammation of the lymph nodes accompanied by fever and chills.

In most cases, inmates said they started wearing tattoos only after they had committed a crime. As convictions increase and the terms of incarceration become more severe, the tattoos multiply. In minimum-security prisons, for example, 65 to 70 percent of the convicts wear tattoos; that figure increases to 80 percent in medium-security prisons, and to between 95 and 98 percent in maximum-security facilities. Female convicts are less likely to wear tattoos, although like men, they are more likely to be tattooed in maximum-security prisons. In the female correctional facility near the town of Kungur in the Perm region—about 700 miles northeast of Moscow—I found only 201 out of 962 were tattooed, but up to 40 percent were tattooed in the high-security





On the prison ringleader, or pakhan, *below, each church dome represents a completed sentence. A soldier, left, who takes orders from the* pakhan, *wears tattoos of* Bogatyrs, *medieval Russian folk heroes.*



prison. As a rule, white-collar criminals do not wear tattoos. Nor are tattoos found among prisoners serving sentences for political crimes.

According to an unwritten law among criminals, a convict without tattoos is looked down on. Such people stand out like white sheep in a black herd. The immediate reaction of newcomers to a camp when they first see the tattooed prisoners is respect and a certain fear, as well as an understanding of the tattooed prisoners' seniority. The tattoos that a convict wears give him material and psychological advantages inside prison.

At the top of the pyramid are the *pakhans*, or "ringleaders." Below them are the ones who carry out the leaders' orders, variously known as authorities, enforcers, fighters, or soldiers. Next come the "men," the hard laborers who are capable of standing up for themselves. Finally, in the lowest category, are the outcasts, or untouchables, the ones who have been broken in prison, beaten, and whipped.

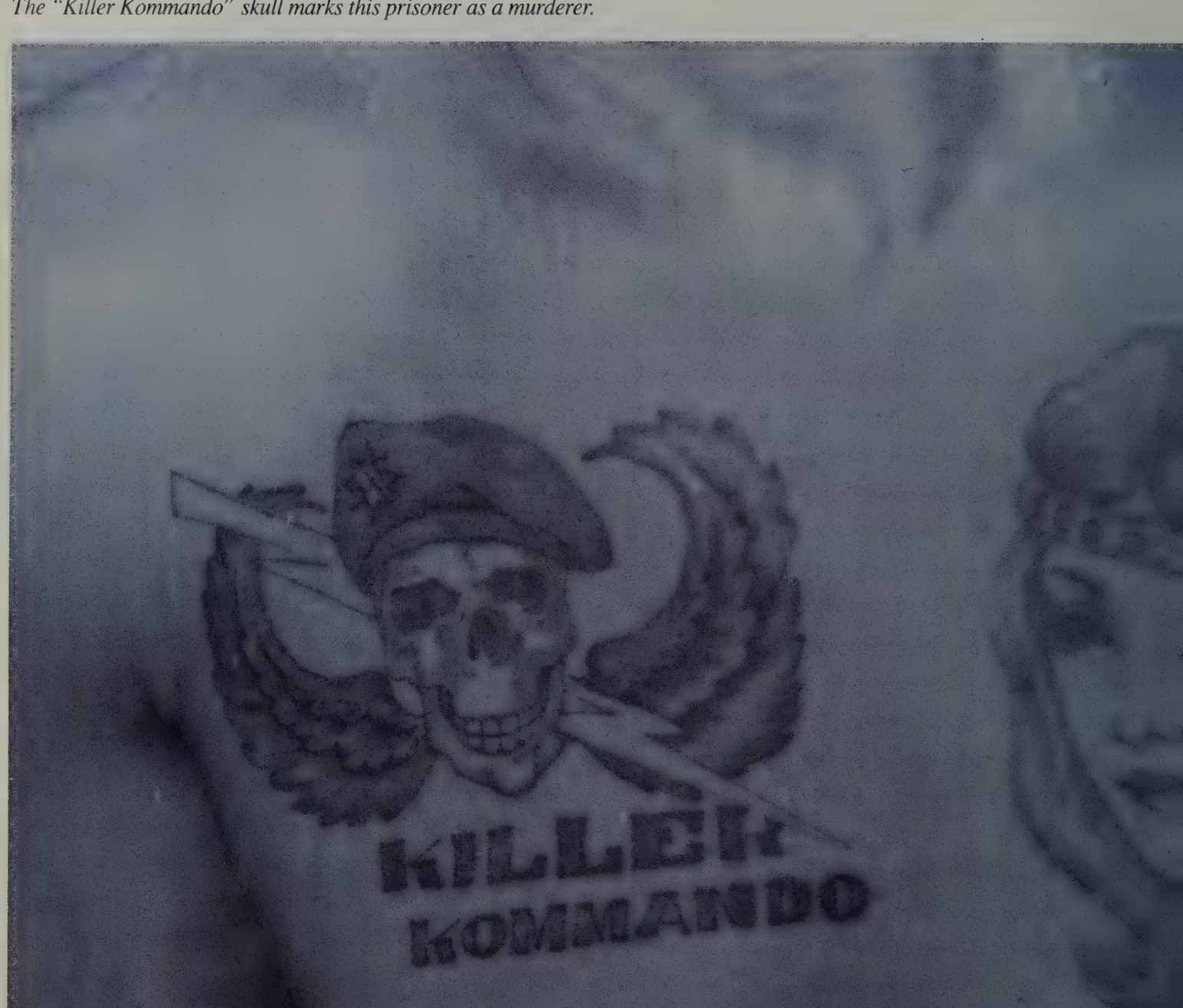
A prisoner's place in the hierarchy of the criminal world depends on his experience as a criminal, his professionalism, his knowledge of the customs, traditions, and unwritten laws of the criminal world. He must be adept at communicating in code, at using cryptography, tapping, gestures, signs, and other secret methods of communication. Tattoos are another kind of secret language, understandable only to the initiated.

The *pakhan* and the authorities usually come from the most common and widespread type of crime network, the *vory v zakone*. This term describes professional criminals high up in the hierarchy of criminal law, both inside prison and in the criminal culture on the outside as well. An eight-pointed star tattooed across an inmate's chest, just below the collarbone, for example, indicates to other prisoners that the person is a professional criminal. When a convict has that same symbol tattooed on his kneecaps, it means that he has an anarchical world view: "I do not bow to other powers. No one can make me fall to my knees."

A cross tattooed on the chest is another symbol used by thieves. Often the person wearing such a tattoo goes by the nickname "Cross." A cross symbolizes subordination, bondage, or slavery. Sometimes it is accompanied by the following text: "A heavy cross is my lot; prison ruined my life." The eight-pointed star is found tattooed most commonly on authorities, while the cross usually indicates a rank-and-file criminal, a commonplace thief.

Finger tattoos are the most common type of tattoos found on criminals. Being always visible, they are a kind of coat of arms, while tattoos on other parts of the body are often covered up by clothing.

The "Killer Kommando" skull marks this prisoner as a murderer.



One simply needs to know how to "read" this open book. Each finger tattoo stands for a conviction (in slang, a trip through the "zone"—the penal colonies). One repeat offender had two tattoos on each finger (but none on the thumbs), indicating sixteen convictions. The pictures and symbols are supposed to correspond with the criminal's deeds. Punishment for a person wearing incorrect symbols is extremely severe, sometimes even death.

A prisoner can learn a lot about his bunkmates by looking at their fingers. A black-and-white diamond means the convict pleaded not guilty and is a bitter prisoner and a dangerous neighbor. A domino with six dots indicates a *shestyorka,* a broken man who need not be feared. A gambler wears the symbol of a suit of cards (a spade, a diamond, club, or heart). A skull or a pirate between the fingers means a murderer, sadist, or robber. The dollar sign ($) indicates a "bear hunter," a thief who can open safes. Three dots tattooed on a woman's hand means she is a thief.

A sailboat tattooed on the chest can mean simply that the criminal loves the

ea, although such a tattoo can also mean
iat the convict is a traveling thief, with no
ome base, or that the person yearns for
eedom and plans to escape from prison.
I am a free man and iron bars cannot keep
ie here against my will." Indeed, tattoos
ive intentionally mixed messages.

A person wearing a tattoo of a tree
ranch is a so-called Polish thief, one who
as left his gang and works in isolation.
raditionally, professional thieves are not
ipposed to engage in any useful activity
iat could benefit society but rather must
ve off their "professional" earnings, that
, on their income as a robber or a thief.
urthermore, they are not supposed to
ommit any other type of crime except
bbery.

Four-time offender B. gave the follow-
ig explanation for the tattoos on his body:

Iy first three convictions were for robbery.
Vhen I was sitting out those sentences I had
ttoos done that symbolized my trade—an
ght-pointed star on the shoulders. My last
entence was for beating up a woman. When
ıy crime became known in the penal
olony, I was told that I no longer had the
ght to be a thief. In other words, my life as
thief is over. Now my trademark indicates
iat "I am alone on an iceberg" [a fallen tree
ranch].

Often, words tattooed on prisoners'
odies mean one thing but the words' indi-
idual letters are acronyms with other
ieanings. For example the letters in the
ussian word for cat, *kot,* stand for "native
rison inmate." However, a cat's head
cross the chest means that the person
ould easily doublecross, lie, or rip some-
ne off. The letters in *Berlin* stand for "I
ill be jealous of her, I will love her and
ate her." *Vino,* the Russian word for wine,
ands for "return and stay for a century."
A picture of a beetle, *zhuk,* indicates a
ickpocket, but when the word *zhuk* is
pelled out, it means "good luck with your
bbery." The Russian word for snow
opard, *bars,* stands for "beat the Party
ctivists, knife the bitches."

Facial tattoos fall into a special cate-
ory. Typical facial tattoos include
wastikas, prison bars, the words "slave of the zone," "junta," or "Communist Party slave." Facial tattoos are usually the result of the "card game of chance," a particularly popular pastime with convicts. When a loser runs out of money and valuables, he agrees to fulfill any demand of the winner, even murder. The winner can make the loser his slave, sodomize him, or force him to get a facial tattoo of his liking. The loser will often willingly agree to the facial tattoo, since he knows it can be removed in a surgical procedure performed in the prison hospital. Once in the hospital, he has a good chance of being transferred to another penal colony, where he can escape his former debts and bondage.

The trademark tattoo of murderers is a skull with a dagger through it (sometimes

Mysnik's Favorite Tattoo

by Neela Banerjee

As a reporter, I had come to Perm to interview Arkady Bronnikov, an expert on convict tattoos, and then to speak with a tattooed prisoner for an article. Initially, my second request had met with resistance. The colonel in the interior ministry explained: "Having tattoos done in prison is illegal, you know. It used to be widespread in the 1950s, but no longer."

In Russia, getting one's way is often a matter of waiting and asking variations of the same question until one hears "yes." After two cups of tea and reluctant phone calls to local prisons, I was put in the charge of a major and taken to Correctional Labor Colony 19, a maximum-security prison on the outskirts of Perm.

Once inside, we were guided by the warden to a lookout post and to meeting rooms overlooking the prison yard. The yard was divided like a pie by whitewashed walls, and in the center was a low building that apparently housed cell blocks.

After some time, a guard opened the door, admitting a slender, sinewy, six-foot-tall man, with dark, stubbly hair and darting blue eyes. His navy prison uniform was undone at the neck, and he had rolled up his sleeves. A crude mermaidlike figure was tattooed on one of his forearms, and tattoos covered the exposed part of his chest and collarbone.

Thirty-year-old Andrei Mysnik was serving a fifteen-year term for killing a Leningrad policeman in 1981. At first he chuckled nervously, self-conscious at the unexpected attention. He put his fists on the table, and as he looked down, I saw the Russian words for "do not wake" etched on his eyelids. Opening a fist, he pointed out two rows of tattoos across his knuckles: One was a beetle, a good-luck charm in burglary, his speciality; another of his finger tattoos indicated that he had spent half his life in prison.

At the behest of the major, he unbuttoned his shirt to reveal two bearded, robed sages conferring. Right below his throat, he had an ugly scar that looked like an old burn. It had once been a swastika, but prison authorities forced him to have it surgically removed.

Mysnik's favorite tattoo fanned across his back: a prehistoric scene, with pterodactyls and tar pits and, in the middle, a dinosaur biting another on the neck. "This is the criminal world to me," he said, explaining the tattoo. "One way or the other you get nailed." Already half undressed at this point, Mysnik had lost his initial shyness and reached to undo his belt buckle to show us the tattoos on his legs. We demurred. He buttoned up his shirt and asked for my autograph so he could prove to his buddies that he had been interviewed by a Western journalist.

After a vodka toast with the warden, the major and I climbed into the sedan again to head back to Perm. The major chattered on, but I stayed quiet, thinking about Mysnik and how the inky pictures seemed too extravagant for his slender back and for the decrepit prison.

Reporter Neela Banerjee worked in the former Soviet Union for three years.

Tattoos of a bracelet on the right hand and a card suit across the fingers identify a gambler.



the dagger is below the skull) or a skull with bolts of lightning zigzagging through it. Sometimes the words "Killer Kommando" are tattooed below the skull, which is usually topped with a beret or some other hat. Bird wings on both sides of the skull indicate that a life has left this world. Murderers also wear tattoos of pirates, a tombstone cross, a spade from a deck of cards (the winning suit in a game of chance for money), a severed head or a human skeleton, and heads of predatory animals such as wolves, rats, tigers, lions, and snow leopards.

Drug addicts, as well as drug pushers and manufacturers, wear a variety of symbols: needles for shooting up; gin pouring out of a bottle; a beetle or a fly caught in a spider's web (a symbol that means "I'm mixed up in drugs like a beetle in manure and I'll never get out"). Addicts are marked by the flowerhead of a poppy, a deformed skull, the devil on a rocket flying in circles toward the moon with the text: "I'm headed for the moon for marijuana." A twisted snake, usually tattooed on the forearm and accompanied by the words "no blood flows through my veins, only morphine," gives a clear message of inescapable addiction. Addicts often cover their arms and legs in dark tattoos in order



A Bogatyr *battling a serpent, left, is the mark of a soldier, one who carries out orders from a ringleader. Religious themes, below, are popular tattoos, although few prisoners are religious.*

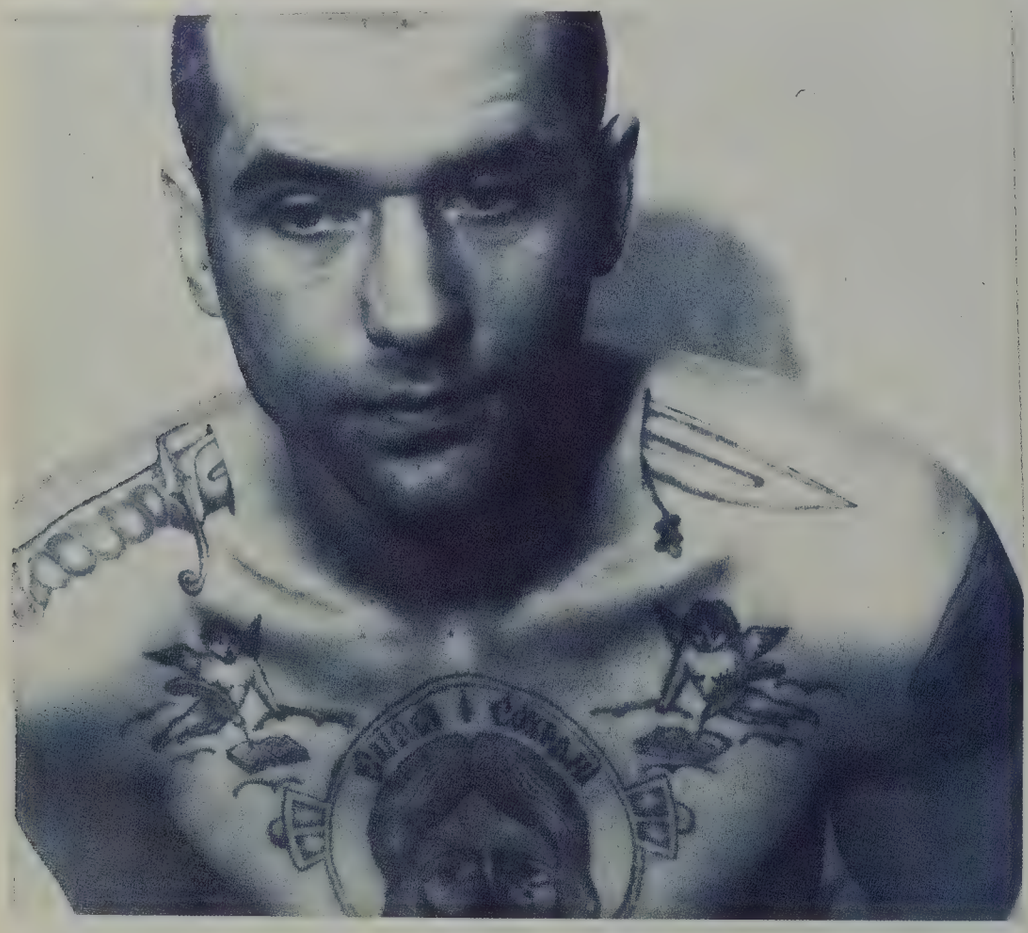


to hide needle marks. Such tattoos generally do not have any special meaning.

The lowest of the low in the prison pyramid are the men who have been raped, and they account for up to one-quarter of the population in the zone. According to an unwritten law in camp life, anyone convicted of a sexual crime deserves to be raped. Law-enforcement agents convicted of crime are usually incarcerated in a special penal colony for police, but if they end up in an ordinary prison, they are also fair game for rape.

The pederast—variously dubbed washed-out, dirty, scab, insulted, violated, and Armenian king—is a complete outcast. His bed is underneath the bunk or next to the latrine. He has to do all the dirty work, from cleaning the toilet to washing the bed sheets. Forced to eat out of a spe-

Inmates forcibly tattooed a dagger on a man, below, convicted of sexual crimes. The elaborate tableau of a Madonna and child, right, probably took years to complete.





cially marked bowl and given feminine nicknames, he is tormented, frequently raped, and forcibly tattooed. Among the symbols that are used are the black eyes of a fly, commonly tattooed around the nostrils, on the cheeks, upper lip, ear lobe, near the eyes, or on the neck, and a round sun with rays radiating from it, a black spot in the center of the sun, and then white and black circles (the symbol is ironic, since it would normally mean "I am in a circle of friends").

The corrective labor system in Russia is ineffective, giving top priority to work production plans. Instead of rehabilitation, convicts in prisons and in penal colonies receive advanced training in their criminal fields, and this is reflected in tattoo art. Body tattoos are often statements such as "The district attorney is not a teacher and prison is not grade school," and "For a convict, prison is a crime college."

Criminals have many motives for wearing tattoos. Some wear them for reasons of vanity, to show off in front of one another. Still others are intimidated into getting tattoos by more seasoned criminals. Others want to prove themselves, to show their bravery and strength, to prove that they are undeterred by pain. Words and symbols tattooed on their bodies state profession, association, the number of convictions, place in the "table of ranks," or a convict's place in the hierarchy of the criminal world. One woman had the number "1968" tattooed on the inside of her lower lip, which she explained was a memorial tattoo for her incarceration.

Tattoos are like a passport, a biography, a uniform with medals. They reflect the convict's interests, his outlook on life, his world view. There are certain "distinguished" tattoos that a convict earns the right to wear—visible signs of his authority and prestige. A prisoner has nothing of his own, not even decent clothes, only the changeless prison garb. Because the only thing that belongs to a prisoner is his body, it can be violated or bartered or turned into a picture gallery. □



Venus, the most dazzling object in the night sky after the moon, is named for the Roman goddess of love and beauty. In Sandro Botticelli's The Birth of Venus, *the mythological beauty is blown ashore on Cyprus.*

Galleria degli Uffizi, Florence; Bridgeman Art Library



A Goddess Unveiled

Piercing the clouds of Venus with radar, Magellan *has revealed our sister planet to be something of an old floozy*

by Harry Y. McSween, Jr.



My parents had three children—two sons and a daughter. My siblings and I share the same gene pool, but you would never know it from our career choices. My sister is a musician, my brother is a tennis pro, and I am a scientist. Although I like to fancy myself as being musically knowledgeable and a fair doubles player, the reality is that I am probably neither, and my sister and brother likewise have little aptitude for science. We three are a lot alike and, at the same time, as different as night and day.

So, too, are Venus and Earth, sometimes described as sibling worlds. Both planets were constructed basically of the same matter, at about the same time, and have similar masses and densities. But until very recently, we knew almost nothing about the surface appearance of our sister planet, even though she lives just next door. Viewed from afar as the morning or evening star, she has often been compared to the shimmering goddess, called, at various times, Ishtar by the Babylonians, Aphrodite by the Greeks, and Venus by the Romans. In more recent cultures, the name Venus remained synonymous with matchless beauty, as illustrated by Botticelli's *Birth of Venus* or Frankie Avalon's sixties' love song "Venus." New planetary observations, however, reveal that up close this goddess is more like an old floozy, her roughened and pocked complexion hidden under caked-on makeup of thick, creamy yellow clouds. The high reflectivity of this obscuring cloud bank gives the planet its dazzling brightness in our night sky.

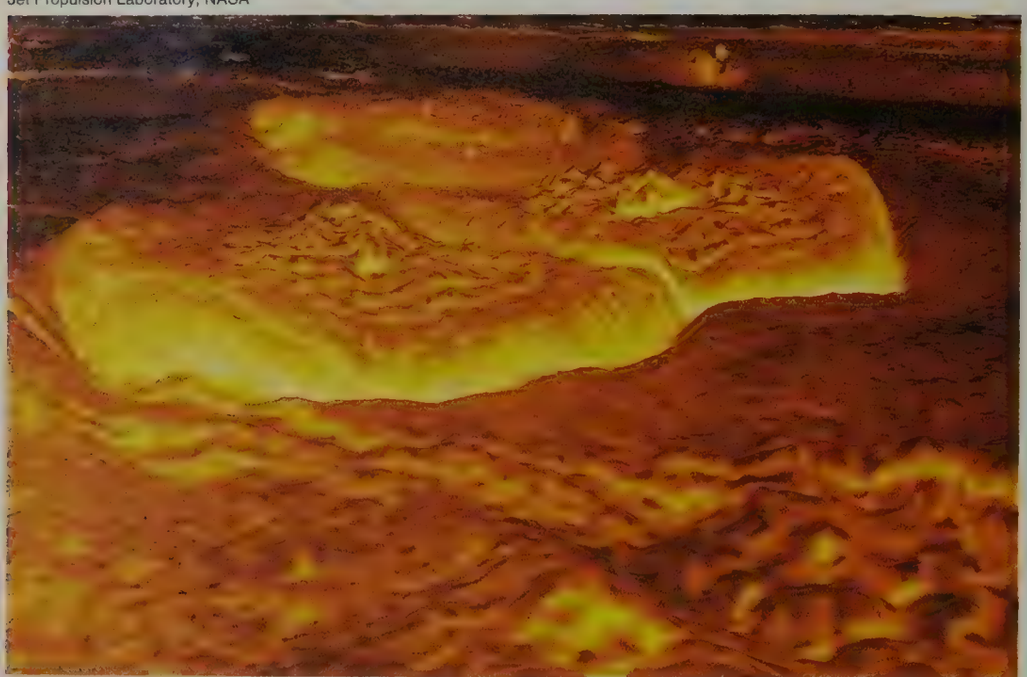
There has been no shortage of scientific conjecture about the appearance of Venus under her swirling yellow veil. The obscuring mists have invoked fantasies of a hazy, swampy world reminiscent of the Mesozoic Earth, populated with lush vegetation and even foraging dinosaurs. Spectral studies, however, showed not even a hint of water vapor; instead, the clouds

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Adapted from *Stardust to Planets: A Geological Tour of the Solar System*. Reprinted with permission from St. Martin's Press, Inc., New York, N.Y. ©1993 by Harry Y. McSween, Jr.

Using data from Magellan, *a computer-generated image, below, shows four overlapping dome volcanoes on Venus. They are fifteen miles in diameter and half a mile high. Another computer-generated landscape, right, shows lava flows from Gula Mons, the volcano on the left, which rises almost two miles above the surrounding plains.*

Jet Propulsion Laboratory; NASA



NASA



were found to be composed mostly of carbon dioxide. Other planetary researchers then surmised that the pervasive carbon dioxide blanket had formed by the reaction of Venus's water with a vast reservoir of gooey hydrocarbons, implying the existence of a globe-encircling oil slick of nightmarish proportions. Still others argued that water-vapor lines were absent from the Venusian atmospheric spectrum because surface temperatures were cold enough to condense all of the water as liquid, which combined with the carbon dioxide in the atmosphere to make seas of carbonated seltzer water. Later temperature measurements showed the surface to be hotter than a self-cleaning oven, causing the oil slick and fizzy ocean hypotheses to be supplanted by the notion of a hellish planetary greenhouse run amok.

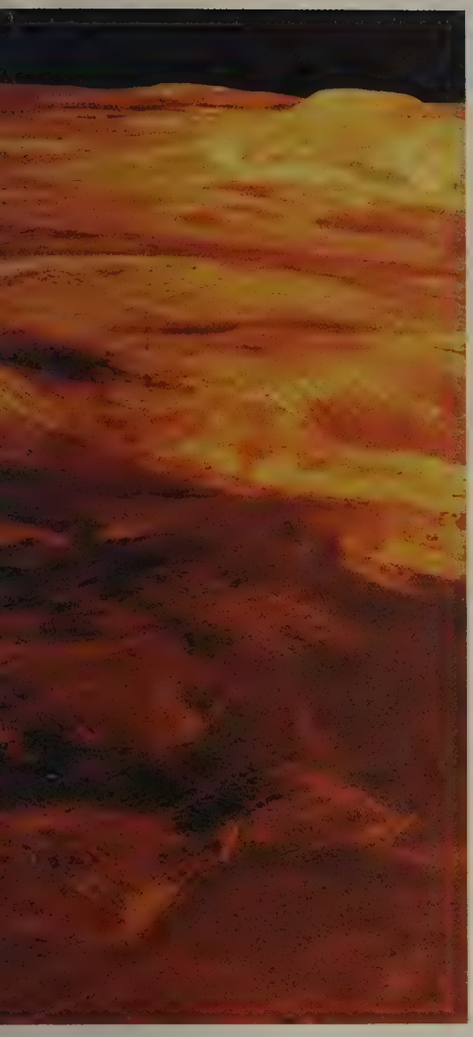
The true face of Venus was finally revealed when radar measurements pierced the obscuring caul of carbon dioxide and sulfuric acid vapor. Several decades ago, the first goddess voyeurs, who prefer to be called radio astronomers, snatched murky glimpses of the planet's surface by beaming powerful radar signals at Venus and catching the reflections in a huge dish at Arecibo, Puerto Rico. The variations in times required for these reflected signals to return to Earth were then converted into planetary surface elevations. The result was a picture of surface relief, a likeness more akin to a carved cameo than to a photograph. The resolution of individual features was not very good, however, because the distance that the signals had to travel was so great compared to the height differences of surface features. What was needed for a better view was a radar platform much closer to Venus, an orbiting peeping Tom with its nose pressed against the atmospheric window.

The first spacefaring *paparazzo* was *Pioneer-Venus,* which reached the planet in late 1978 and immediately began bouncing radar signals off the surface. The picture of Venus that emerged from the *Pioneer* data, and from the earlier Arecibo results, was of a planet with high-standing "continents" surrounded by low-lying "basins," something like Earth if its oceans had been miraculously emptied of water. But what do descriptive terms such as continents and basins mean on a planet with no water?

Venusian highlands, defined as those areas that have elevations well above the mean planet radius, are called *terrae,* as are those on the Moon. The term *planitiae,* Latin for "plains," is given to the intervening, basinal regions. Other regions of rolling plains lie at elevations near the mean planet radius. By convention, the major features on Venus are named for females, both real and mythical. Circular forms are named for notable historical women, as in the craters Dickinson (Emily) and Earhart (Amelia), and other features bear names of mythological goddesses and heroines, as in Aphrodite Terra and Guinevere Planitiae. A glaring exception to this system is Maxwell Montes, a great mountain chain that honors the male physicist who developed the theoretical underpinnings of radar. Two other small highlands regions, Alpha and Beta, have genderless names that were grandfathered in when the planet's nomenclature turned feminist.

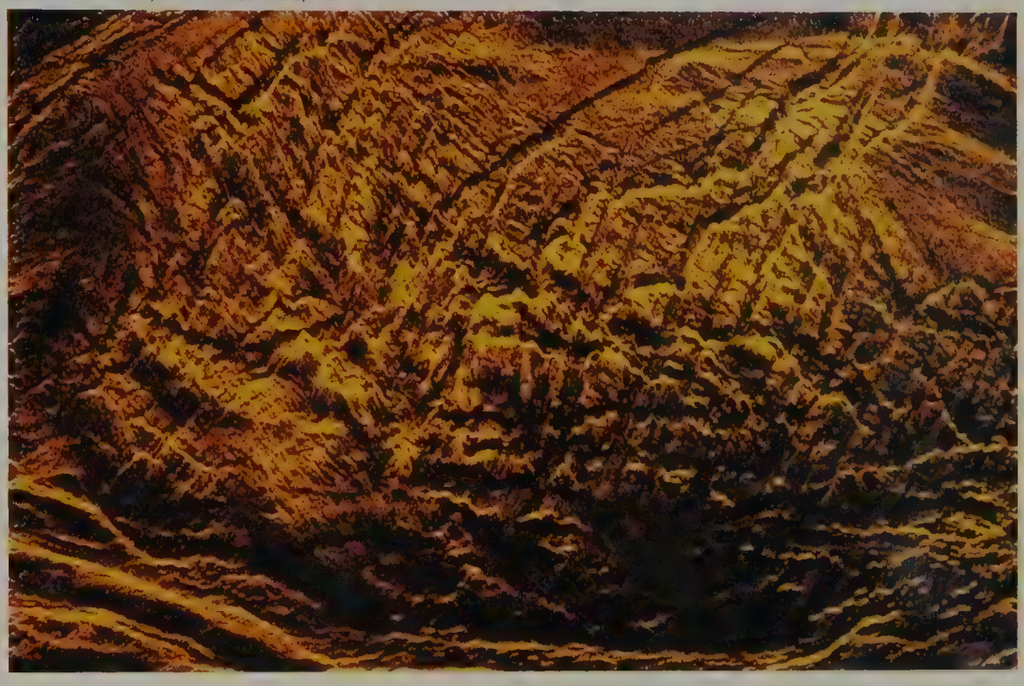
Beginning in 1983, the Soviet orbiting spacecraft *Venera 15* and *Venera 16* provided new radar images with even higher resolution, delineating Venusian features as small as a half mile across. But the most spectacular views of the goddess have been provided by *Magellan,* an American spacecraft inserted into a near-polar Venusian orbit in 1990. *Magellan* has mapped virtually the entire surface, and its improved radar system has resolved blemishes almost as small as a football field.

Venus sat remarkably still for her unsanctioned *Magellan* portrait, but not perfectly motionless. The planet rotates very



In the Freyja Montes region, below, the crust has been uplifted and stretched over an area some seventy-five miles across. Large faults crisscross the uplift where sections of the crust have dropped, creating cliffs and intersecting valleys a few miles wide. The wrinkles surrounding the uplift were caused by compression of the crust.

NASA/Mark Marten; Photo Researchers, Inc.



owly, requiring 243 Earth days to make ne complete turn, corresponding to one enusian day. A *Magellan* mapping cycle as designed to take one full day as reck-ned on Venus. As the planet slowly ro-ted, every place on the globe eventually ched its way underneath *Magellan*'s or-tal position. To radar beams, the goddess as as naked as a jaybird, with the space-aft poised to expose her every flaw. Dur-g the first mapping cycle, the spacecraft ade 1,789 orbits, continuously recording dar images of the swatches of terrain low its flight path. The resulting pictures nsisted of long, visual "noodles," repre-nting strips of ground 12 miles wide and 0,500 miles long. The photographic rips from adjacent orbits, which over-pped slightly, were ultimately laced to-ether to make photomosaics.

The sheer quantity of information pro-uced by *Magellan* is staggering. During e first mapping cycle, the spacecraft sent Earth 800 million bits of radar data, overing most of the Venusian surface. he surface of Venus is now better charac-rized than that of our own planet, be-use features over much of Earth's sur-ce are discreetly cloaked by water. A few sfiguring blemishes on the goddess pro-de particularly interesting geological erspectives.

Planets, like babies, are born with unwrinkled skin and become gnarled with age. Earth's most prominent wrinkles are towering mountain ranges, such as the Rockies, Alps, Himalayas, and Urals, as well as sinuous midocean ridges that snake along the ocean floors. These features are the direct result of huge, segmented slabs of rigid crust that move about and jostle each other, sometimes crunching together and at other times pulling apart. Plate collisions crumple, fracture, and uplift the crust, producing the elongated belts of buckled and faulted rock that we recognize as mountain chains. Midocean ridges occur where plates pull apart, creating yawning fracture systems that swell with magma from below.

What drives Earth's restless plate motions is internal heat, rising through the mantle in great plumes that bring hot rock and magma toward the surface. In other areas, the opposite process occurs, as cold crustal rocks are dragged down into the mantle and recycled. The rigid crust perched above these roiling cells breaks into plates that are pushed away from areas of upwelling and dragged toward areas of downwelling. The surfaces of the Moon, Mercury, and Mars have no plates, but these worlds are very different from Earth, both in terms of size and the amount of heat in their interiors. Because of its size, Earth retains enough internal heat to create the convection cells that power plate movements. We might predict that plate tectonics also would occur on its similar-sized sibling.

The unsightly wrinkles on Venus are every bit as noticeable as their terrestrial counterparts, but they are not nearly so common. Wrinkled crust occurs mostly on *terrae*. It often forms complex patterns of intersecting ridges and valleys called *tesserae*, meaning "tiles" in Latin. Several episodes of tectonic movement must have occurred to produce the different orientations of the folds.

These leathery wrinkles are clearly tectonic structures, but they apparently did not form during collisions of large, rigid plates. From geological studies of Earth, we know that sites of plate convergence are marked not only by elongated mountain belts but also by chains of volcanoes and deep trenches: both are the result of one plate diving beneath the other. Volcanic chains and deep trenches are not associated with Venusian mountain belts.

Venus also lacks evidence of plates pulling apart. On Earth, extension causes collapse, and magmas well up and fill the intervening rifts between the separating

A radar image shows Venus stripped of her clouds. The bright feature in the center is Ovda Regio, a mountainous region of Aphrodite Terra, an equatorial "continent." The large circle to the lower right is the Artemis Chasm, with cliffs a mile and a half high. It forms the border of the largest volcanic corona. Many of the smaller circular features are coronas or impact craters. The dark smudges are ejecta from craters.
Jet Propulsion Laboratory; NASA

plates. Although extensional structures do occur on Venus, they are spread over vast areas of the landscape rather than being localized at plate boundaries. Clearly, the Venusian crust has been crumpled and shortened to make wrinkles, but we could not call this process plate tectonics. The surface of Venus is effectively one gigantic plate that has not broken apart with age, as has Earth's crust.

This difference in crustal behavior certainly cannot be attributed to lack of internal heat and convection on Venus. Her surface is encrusted with thousands of volcanic pimples and blisters, all testifying that the planet's interior is hot and that mantle convection occurs.

The volcanic pimples, euphemistically called domes by planetary geologists, are shaped somewhat like pancakes, typically measuring about fifteen miles in diameter with heights of a half mile or so. Their tops contain numerous, deep pits whose bottoms lie nearly at the level of the surrounding plain, so perhaps the shapes of these features might be better characterized as English muffins. (Similar, but much smaller, domes occur on Earth, where sticky lava with the consistency of toothpaste erupts and hardens.) Complex fracture patterns that decorate the tops of the domes may have formed when already congealed lava was stretched upward as additional pulses of magma extruded from below. Alternatively, molten material in the interiors of the crusted-over domes may have withdrawn to deeper levels, causing the collapse and fracturing of the overlying, solidified lava.

The pimples are distinctive, but the most noticeable of Venus's volcanic disfigurements resemble popped blisters, ranging in size up to hundreds of miles across. Called coronas by geologists, these circles are defined by concentric ridges and moats commonly filled with lava. Many coronas are surrounded by radial networks of "varicose veins," interconnected fractures that resemble spider webs. Soviet researchers have christened these webs, and their associated coronas, arachnoids. These curious features apparently were formed by ascending magmas that did not break the surface but arched the overlying crust upward. The stresses induced fractures in the crust surrounding the coronas. At some later time, the supporting magmas withdrew, causing many of the blisters to collapse, like fallen soufflés, into circular depressions.

The coronas indicate that very large magma chambers existed at one time in the subsurface. Such chambers on Earth, once congealed and unroofed by erosion, are called plutons. But our plutons are normally much smaller than those that must have made the coronas on Venus. Why Venusian magmas should collect into such huge blobs remains a mystery, but this phenomenon produces a distinctive deformity that is widespread on the surface of the planet.

Venus also displays irregularly shaped birthmarks, the traces of lavas flowing on the surface. These flows, some of which can be traced to volcanic vents, often extend for thousands of miles, much farther than comparable features on Earth. They also tend to be thinner, with gentler slopes. The lava that composed these flows must have been extremely fluid, much different from the sticky toothpaste that formed the domes. Perhaps the broiling surface temperature kept these lavas from cooling too quickly.

Domes, coronas and arachnoids, lava flows, and myriads of other volcanic features all indicate that Venus's interior was, and probably still is, awfully hot. Volcanic bumps and sores are widespread but are not localized at plate boundaries, as they are on Earth. Some planetary geologists have coined the term *blob tectonics* to describe the crustal architecture of Venus. What they mean is that heat continually rises to the surface at certain localities, "hot spots" if you will, melting the mantle and generating clusters of large subsurface plutons, or eruptive centers. These hot spots are like blowtorches, burning into the crust from below. Earth, too, has hot spots. Hawaii, for example, is a chain of volcanic islands etched into the Pacific plate as it creeps over a stationary plume. But Venus has no restless plate motions to smear the surface expression of the hot spots. If Venus has a hot, convecting interior, why are there no plates?

One idea is that the frightfully hot Venus surface temperature softens the crust to a greater depth than on Earth. This warming might make the crust behave like chewing gum and so prevent it from breaking into plates. If the crust and the underlying mantle are similarly pliable they may behave as if they were coupled together. This is a very different situation from what exists on Earth, where a partly melted transition zone separates the cooler, rigid plates from the hot, convecting mantle below, allowing plumes to break the crust into plates and drive them around the planet. If Venus has no such boundary, convection may extend through its single-plate crust nearly to the surface, as manifested in the volcanic warts and blisters so common in radar images.

Magellan has revealed that Venus is horribly wrinkled by stress and age. She has had numerous, serious outbreaks of volcanic acne, which have left her pimpled and blistered, harboring lava birthmarks and varicose veins. External forces have also taken a toll; despite a thick atmosphere for self-protection, she has been pockmarked continuously by large meteors, and her face is dirty, stained by long streaks of windborne dust. She has no water to soften her rough edges.

But are we expecting too much of the goddess of love and beauty? She is, after all, Earth's sibling, and our planet is no beauty-pageant contestant either. Perhaps these two sisters look just the way we would want them to. Age has given them character; experience and adversity have made them geologically interesting. Looking carefully at their worn and ravaged faces, we can decipher the processes that have molded and shaped them. Venus, naked to radar, can no longer keep her secrets hidden, and now at last we have begun to learn about her long and interesting geological history. What would be duller, or sadder, than a 4.5-billion-year-old lady with no story to tell? □



A large patch of low-growing willow and birch, below, lies to the right of the road that runs through Elk Park. Opposite page: An elk in winter.

All photographs by Kent and Donna Dannen



Elk Park, Colorado

by Robert H. Mohlenbrock





In the heart of Colorado's Rocky Mountains, west of the nearly deserted mining community of Apex, a rough gravel road climbs steadily through a forest of spruce and pine. After a mile, the road dips into the next valley, and a panorama of the Rockies comes into view, with James Peak rising in the distance. The abandoned Nugget Gold Mine lies on a crest about three-quarters of a mile to the right, while a small, still-operational gold mine nestles in the hillside below. At the foot of the hill, a beautiful, meadowlike opening known as Elk Park fills the broad valley. Through it runs Elk Creek, which draws elk down from the surrounding mountains to drink and browse on some of the vegetation. Except for one privately owned corner, Elk Park is managed by the Arapaho National Forest.

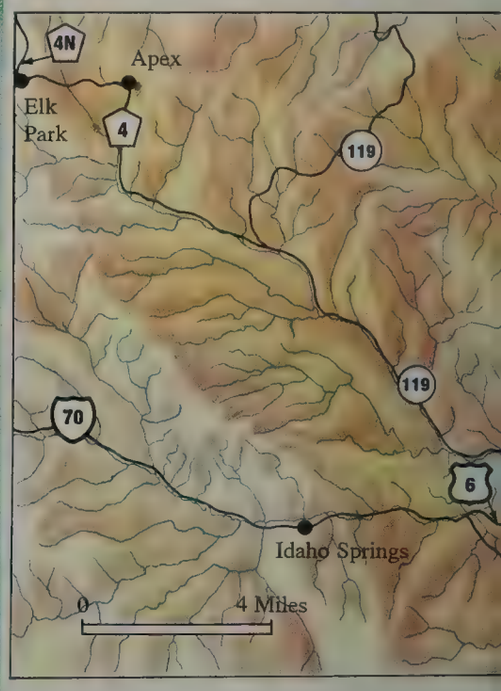
Near where the road crosses the creek is a wetland habitat known as a shrub carr, "carr" being a word of Scandinavian origin that means marsh or fen. Shrubs, none more than four feet tall, grow in and along the creek and adjacent rivulets. Flat-leaved willow, short-fruited willow, and dwarf birch are the most common shrubs, and they are often so close together that little else can grow with them. The birch is

Elk Park

For visitor information write:
Forest Supervisor
Arapaho and Roosevelt National Forests
240 W. Prospect
Fort Collins, Colorado 80526
(303) 498-1100

Joe LeMonnier





unlike most other species of birch. It is no more than three feet tall and its leaves are small, with no coarse teeth along the edges. In addition, the bark does not peel off the way it does naturally on other birches. The two willows, like most willows, are well adapted to moist habitats, with extensive root systems to provide anchorage in the saturated earth.



Seeds on a willow's female catkin are equipped with tufts of hairs for dispersal by the wind.

Willows grow primarily in temperate and boreal climates; hardly any are tropical. Most have leaves that are considerably longer than they are broad, and all willows form simple flowers without petals. The male flowers each consist of one or two pollen-producing stamens and are crowded into long, drooping structures known as catkins. The female flowers are single pistils and similarly grow in catkins. Each willow has both the male and female variety. Most trees that have flowers without petals, such as oaks, hickories, and birches, depend on the wind as the agent for pollination, but willows are pollinated by insects.

A tuft of soft, silky hairs enables the willow seed to be blown a considerable distance from the parent plant. When the light seeds glide onto suitable, moist soil, they can quickly colonize the area. If a seed happens to fall on water, it may float for a few days before lodging in the soil and germinating.

Several species of dwarf willow grow in the American Arctic and above timberline in the Rocky Mountains. Some are less than a foot tall at maturity, but their woody stems qualify them as shrubs. At the other extreme, some willow trees found along streams at lower latitudes and lower elevations grow more than sixty feet tall. The willows along Elk Creek bristle with branches but seldom exceed four feet.

Although the willows fan out into the carr, here and there layers of soil have built up in small clearings. These have become covered with thick mounds of mosses and harbor a diversity of wildflowers, whose display of blooms peaks in August. The heart-leaved bitter cress, with its pure white flower clusters and deeply cleft green leaves, lives in the wettest areas adjacent to the numerous rivulets. The pink pendulous flowers of the Rocky Mountain shooting-star contrast with the white blossoms of the marsh marigold. Two succulents, king's crown and rose crown, reach ten inches above the mosses; their fleshy leaves would seem to be better adapted to desert conditions. Some wildflowers that live among the crowded willows have to grow tall to compete for the sunlight. They include blue monkshood, yellow triangle-leaved groundsel, and tall larkspur.

The terrain rises gradually as one follows Elk Creek toward its source, and the soil becomes drier. About three hundred yards upstream from the road, the thicket of willows and dwarf birch begins to open up, providing more space for the wildflowers. Soon the willow and birch zone ends and plants that tolerate drier conditions take over. Milfoil and locoweed abound in the now pebbly soil, along with scattered six-foot-tall monument plants. A robust member of the gentian family, the monument plant has inch-wide flowers with four yellow-green petals, each marked with small purple spots and bearing two hairy glands that secret nectar to attract insects. This plant is also sometimes known as deer's ears because of the shape of the very fuzzy leaves.

Robert H. Mohlenbrock, professor emeritus of plant biology at Southern Illinois University, Carbondale, explores the biological and geological highlights of the 156 U.S. national forests.



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Second Thoughts

Take my advice, please...

by Roger L. Welsch

I am never sure where science ends and reality begins, but I have it on good authority from a sociologist that human relations are sociology, and that sociology is a science. Which means that I am an expert, because I have been successfully married for thirteen years.

Twice, in fact.

Okay, the first time didn't work out all that well, but there were no homicides, and if you were at all familiar with the circumstances, you'd agree with me that that simple phrase "no homicides" represents a triumph of diplomacy and tact. I learned a lot from the experience of my first marriage, sort of like what a hog must learn from the process of becoming sausage, and I have worked hard at applying what I learned toward doing better this second time around. Anyway, it makes no sense whatsoever to me that the big guns in marriage advice these days have only been married once, if at all. What kind of experience is that?

They say that opposites attract, and that certainly has been the case with Lovely Linda, my current-and-final wife, and me. For example, she's a woman and I'm a man, and those are industrial-grade opposites. But despite our differences, we both know what a successful relationship is built on: *communication*. Whatever the conflicts between two lovers (or for that matter, two neighbors or two nations), those tensions can be resolved with communication—open and honest sharing of opinions, experiences, and credit cards. And whatever we might lack, Linda and I have communication. For example, no anniversary or Valentine's Day goes by, but what Linda tells me how much she appreciates the fine gifts she bought for herself that I would have bought for her if I had remembered.

I recorded a typical conversation between Linda and me just to show how smoothly we communicate. (I offer this with Linda's full knowledge and approval. Believe me, I understand all too well that there is some jeopardy here. Anthropology and folklore fieldwork ethics condemn surreptitious field recording, and with good reason. I have a colleague who once, no kidding, put a tape recorder under the connubial couch with the thought that he and his wife could later share a jovial moment by replaying the resulting tape. The marriage survived, but just barely, and my friend chose the easier course of selling the recorder at a garage sale rather than eating it, which was his wife's suggestion.)

SCENE: *Living room of our home at Primrose Farm. A golden retriever and a black lab pose picturesquely on a mat in front of the fireplace, in which crackles a warm, cheery blaze. There is the smell of popcorn in the air. I sit in the rocker, wearing my lounging overalls; Linda lolls on the couch; we are reading the newspaper. By the light of the fire, our ten-year-old daughter, Antonia, is writing her lessons with charcoal on a shovel.*

ME: Honey, I noticed this morning that the water filter needs changing. If you're not doing laundry tomorrow, I'll shut down the water and work on it. By the way, did you have a chance to pick up my jacket from the dry cleaners?

LINDA: Look at this! Billy Ray Cyrus is performing in Grand Island next week. Would you take line-dance lessons and learn the "Achy Breaky" with me?

ME: It says here that the Rolling Stones have been dropping in on blues bars acros the country. They show up about mid night, lock the doors, and play all night fo whoever is there. Would that be like goin to heaven?

LINDA: You will? That's sweet; I know how much you hate country music. Oh, b the way, do you want me to pick up tha jacket at the cleaners?

ME: Tell me about it! Get this: An Ind car weighs half—get that? Half!—of wha my tractor weighs.

LINDA: Antonia, Dad's talking to you He needs the TV remote control.

ANTONIA: Huh?

Linda: I have class tomorrow, so it wil be up to you to get your jacket from th cleaners.

ME: You did? Great.

ANTONIA: Lucky ate the TV control.

ME: You're telling me. Water ca hardly get through the thing any more.

Considering its value, good communi cation requires so little effort.

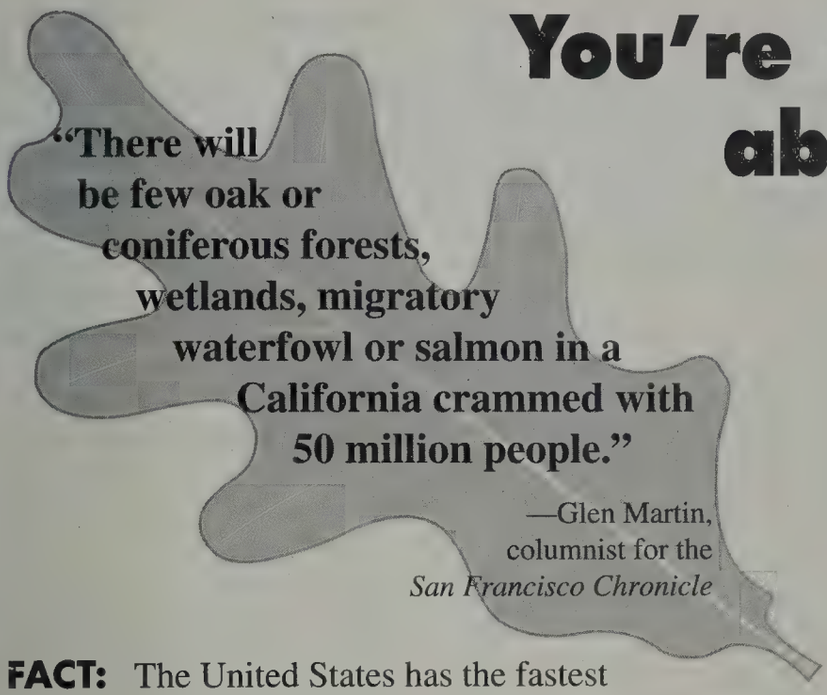
I recognized the importance of commu nication in our relationship soon afte Linda and I were married. We were having supper at my parents' home when my mother said, "Roger, have some Brussels sprouts."

"Roger doesn't like Brussels sprouts," Linda said.

"But I've always liked Brussels sprouts," I sputtered.

"Well, I'm glad you changed your mind," Linda said.

And that settled the issue. How reassuring, even when the topic at hand is so trivial as a food preference, that a possible misunderstanding can be cleared up by communication. (In situations as dicey as marriage, however, nothing is trivial.)



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FACT: Although per capita U.S. auto emissions and use of oil have been cut significantly since 1970, U.S. population growth has negated much of these gains according to John P. Holdren, professor and head of Berkeley's Energy and Resource Group.

FACT: Nearly all population growth after the year 2000 will be from post-1970 immigrants and their descendants, according to studies by the Census Bureau and demographer Dr. Leon Bouvier of Tulane University.

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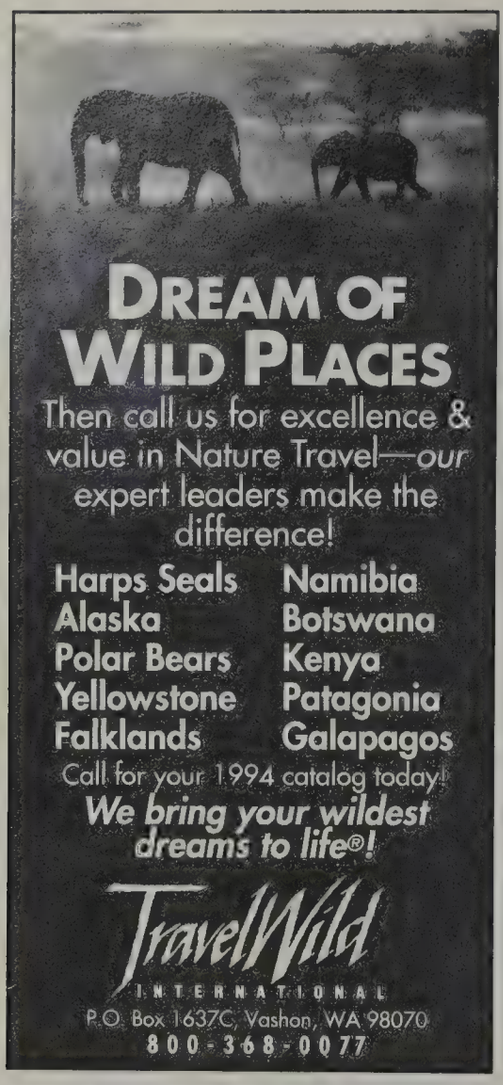
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As our relationship matured, Linda and I once found ourselves drinking our morning coffee and discussing mortality. (It happens.) I expressed my hope that if anything should happen to me—I am considerably older than Linda and a good deal more fragile—she would continue her life, find new happiness, and with all probability, a new husband. "No, Roger," she said, her voice choked. "If something should happen to you, I'd never marry anyone else."

I put my arms around her shoulders. "Love, you are a young and attractive woman. It would be crazy for you to devote yourself to a memory, no matter how precious. Trust me. If something happens to me, you have permission to remarry."

She looked up at me with surprise. "No, Rog, I'll never marry again." I embraced her. I patted her back. "I'll fool around," she mumbled with determination, "but I sure as heck won't get married again. Nosiree."

Once again, I was comforted that we understand each other. Whatever firestorms swirl around us, from war in Bosnia to squabbling about the flood up in town, down here at Primrose F we are open books to each other.

Even when we are asleep, we com nicate. A few nights ago I was just d ping off when I snorted involuntarily woke myself up.

"What?" muttered Linda, rudely av ened from her own slumbers by my r noises.

"I just woke myself up with my snoring," I explained.

"You woke me up to tell me you v snoring?"

"No, I woke me up."

"Well, what woke me up?"

"I guess I did."

"And you woke me up to tell me th

"Good night."

"Good night."

Marriage is, after all, not simply a u of the flesh but also a wedding of mind study in social interaction. And I, for wouldn't have it any other way.

Folklorist Roger L. Welsch lives on a farm in Dannebrog, Nebraska.



"I got four hugs today. How'd you *do?"*

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Coffee, Tea, or Opium?

In 1838, a Chinese drug czar confronted the Age of Addiction

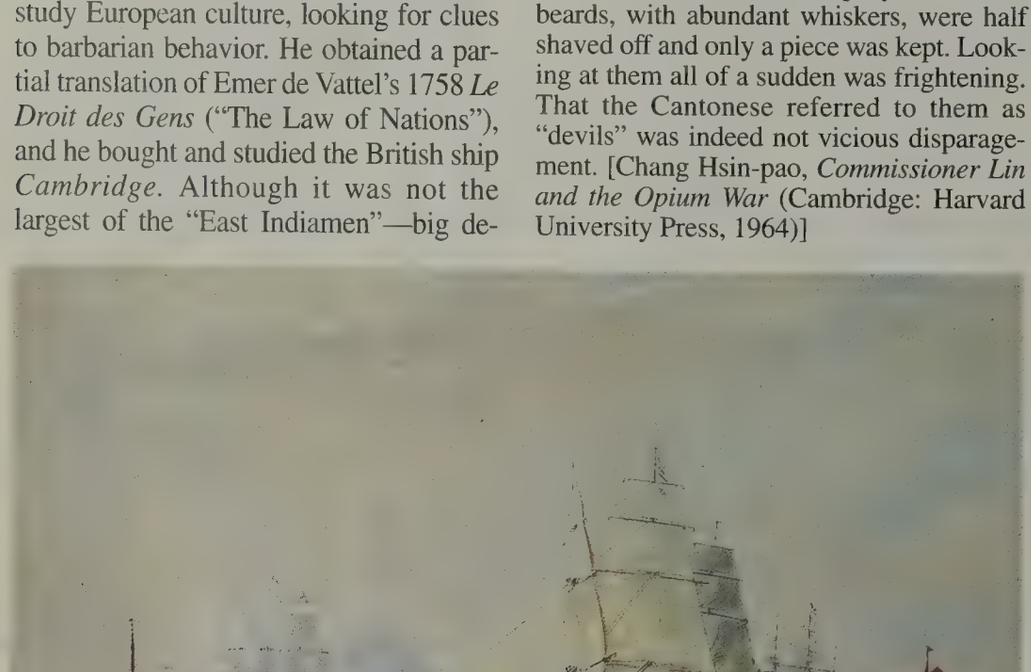
by Samuel M. Wilson

In 1839, China's commissioner for foreign trade, Lin Zexu (Lin Tse-hsü), was running out of diplomatic options. Traders from the East India Company and other European enterprises were pressing him ever more forcefully to turn a blind eye to the illegal importation of opium into his country. They were implicitly backed by Britain's heavily armored warships—such as the *Blenheim* and *Wellesley,* carrying seventy-four cannons each—which could crush China's navy and lay waste to her ports. But the opium trade was damaging public health and bleeding China of her wealth. In 1838, the Manchu emperor had given Lin extensive power and ordered him to control the demand of China's people for opium and force the barbarian merchants to cut off the supply.

After his appointment, Lin began to study European culture, looking for clues to barbarian behavior. He obtained a partial translation of Emer de Vattel's 1758 *Le Droit des Gens* ("The Law of Nations"), and he bought and studied the British ship *Cambridge*. Although it was not the largest of the "East Indiamen"—big defended freighters—and although it had been stripped of its guns and its intricate rigging was a mystery to Lin's sailors, the ship was ample evidence that these British were clever at naval warfare.

Lin also visited Macao, the Portuguese trading entrepôt near Canton, and carried out some anthropological fieldwork:

> As soon as I entered the wall of Macao, a hundred barbarian soldiers dressed in barbarian military uniform, led by the barbarian headman, greeted me. They marched in front of my sedan playing barbarian music and led me into the city.... On this day, everyone, man and woman, came out on the street or leaned from the window to take a look. Unfortunately the barbarian costume was too absurd. The men, their bodies wrapped tightly in short coats and long "legs," resembled in shape foxes and rabbits as impersonated in the plays.... Their beards, with abundant whiskers, were half shaved off and only a piece was kept. Looking at them all of a sudden was frightening. That the Cantonese referred to them as "devils" was indeed not vicious disparagement. [Chang Hsin-pao, *Commissioner Lin and the Opium War* (Cambridge: Harvard University Press, 1964)]



Opium clippers off the coast of China
National Maritime Museum, Londo

Although the Chinese forbade opiu importation, willing trading partners we easily found among the Chinese me chants. And if trade became too difficu for the foreigners in the principal port Canton, there were a thousand miles coastline, and thousands of miles more inland borders, through which opiu could be transported. Lin saw that th opium trade was ruining China. Informe by his reading of de Vattel and by his e tensive dealings with the British represe tatives, in early 1839 he appealed Queen Victoria, attempting to conceal th sense of superiority that the Chinese rule felt toward Westerners:

> We have heard that in your honorable n tion, too, the people are not permitted smoke [opium], and that offenders in th particular expose themselves to sure punish ment.... Though not making use of it one self, to venture nevertheless to manufactu and sell it, and with it to seduce the simp folk of this land, is to seek one's own livel hood by exposing others to death, to see one's own advantage by other men's injur Such acts are bitterly abhorrent to the natu of man and are utterly opposed to the way of heaven.... We now wish to find, in coop eration with your honorable sovereignt some means of bringing to a perpetual en this opium, so hurtful to mankind: we in th land forbidding the use of it, and you, in th nations of your dominion, forbidding i manufacture. [Chang Hsin-pao, *Commis sioner Lin and the Opium War*]

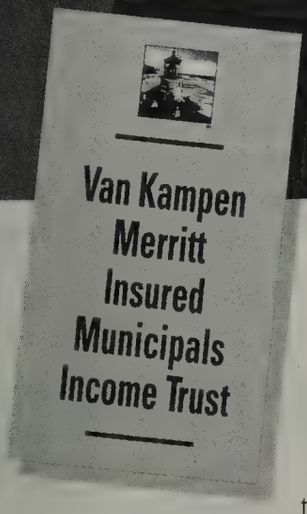
The British were the biggest traders i China, but merchants from the Unite States were present too. Lin considere petitioning this other, possibly significan state, but understood that twenty-fou chiefs governed the American people, an thought that communicating with them a would be too difficult.

In his letter to Queen Victoria, Li sought to explain the situation logically Earlier communications from the Chines government had not been so diplomatic The commander of Canton had sent a

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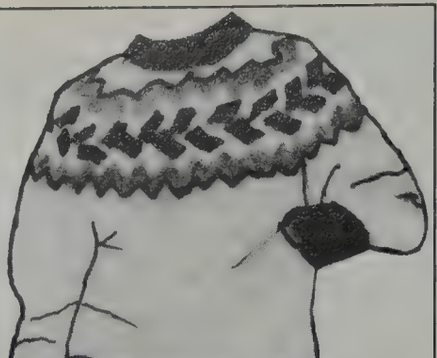
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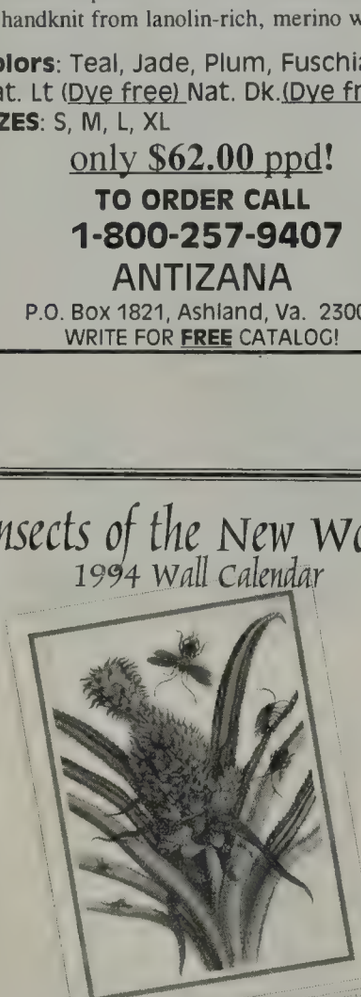
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edict to the Western traders demanding, "Could your various countries stand one day without trading with China?" This threat came in part from the Chinese leaders' delusion that the British would die if deprived of tea, China's largest export (a delusion the British may have shared). The same edict took note that, according to the Western press,

> your motives are to deplete the Middle Kingdom's wealth and destroy the lives of the Chinese people. There is no need to dwell on the topic that the wealth of the Celestial Empire, where all five metals are produced and precious deposits abound, could not be exhausted by such a mere trifle, but for what enmity do you want to kill the Chinese people?

China had withstood barbarian traders without difficulty for two thousand years. But now it was feeling the aftershock of the Western encounter with the Americas and with the closely related expansion of European influence across the globe. The importation of opium reached staggering proportions in the early nineteenth century after the British-run East India Company took control of the drug's production in India. During the trading season of 1816–17, about forty-six hundred 150-pound chests of opium entered China. This number rose to 22,000 by 1831–32 and 35,000 by 1837–38. That was more than 5.25 million pounds of opium, the carefully collected and dried sap extruded from 4.8 trillion opium poppies.

The period from the seventeenth century to the present could be termed the Age of Addiction, for the international economy and the fortunes of nations depended on trade in addictive or semiaddictive agricultural products. The you United States exported tobacco, the ha for which spread rapidly across Euro Africa, and Asia. The Spaniards carri the New World practice of tobacco smo ing to Europe and the East Indies, and its popularity spread, the plant came to widely cultivated throughout the O World. In their Indonesian colonies t Dutch tried filling their pipes with a co bination of opium and tobacco. The Ch nese continued to smoke the opium, b left out the tobacco.

The British became addicted to t carefully processed leaves of *Camell sinensis,* or Chinese tea (originally, Chi was the only exporter). Caffeine-rich co fee was another drug for which Europea and others developed a craving. A nati plant of Ethiopia, coffee's range of cultiv tion expanded hand in hand with Eur pean colonialism. Perfect growing conc tions were found in both the New Wor and Southeast Asia, giving rise to the e otic names for coffee familiar today: J maica Blue Mountain, Mocha Java, Gu temalan, Sumatran, and Colombian. The and other nonessential but deeply desire plant products—cocaine, chocolate, a marijuana—have captured huge market

Addictive substances are wonderful e ports for the countries that produce a ship them. They are highly valuable a compact agricultural products that can exchanged for hard currency, and the d mand of addicts is—for physiological re sons—what economists would call high inelastic. Farmers get much more fro their land and effort than they would



A late nineteenth century engraving of an opium den in London's East End
Hulton-Deutsch Collection, London

wing things for a local market, and ddlemen on both sides of the border get . The losers in the transaction—apart n the users themselves—are the im- ting countries, which run up uncontrol- e trade deficits.

From the opening of the Silk Road in Middle Ages, Western countries were er to obtain Chinese spices, fabrics, tea, viewing them as superior to Euro- n products. The problem for England other nations was that they had very e that China wanted, so they had to pay he most respected and accepted inter- ional currency, Spanish silver dollars. th good reason, the Chinese thought the tish could not live without tea. About China would take in trade was British olen and cotton cloth. American mer- nts, lacking England's textile manufac- ng infrastructure, struggled still more find anything the Chinese would take in de. They too paid mainly with Spanish er, but they also brought natural prod- s—sealskins and other furs from the rthwest Coast, aromatic wood, cotton, d American ginseng—with which to de (*see* "Yankee Doodle Went to Can- ," *Natural History,* February 1984).

By capitalizing upon a massive addic- n to smoked opium in China—and in bstantial measure helping to create it— gland and the other Western nations fted the balance of trade in their favor. social historian Fernand Braudel put it, hina was now literally being paid in oke (and what smoke!)." Most of the t of what England traded was woven ton, also grown and spun in India. In re- n, at the time of Commissioner Lin's peal to Queen Victoria, the Chinese re trading about 60 percent tea, 12 per- nt silks, and most of the rest, about 25 rcent, silver and gold.

The opium trade was not the only rming foreign influence in Lin's day. e barbarians seemed to have designs on inese territory. The port of Canton lay rty miles upriver from the great Gulf of nton, twenty miles wide and fifty miles g. At the western approach to the bay s the Portuguese trading colony of acao, which the Chinese had allowed to ist since 1557. On the other side of the lf lay the island of Hong Kong, which British sought to turn into a secure adquarters for their trading operations. en if the Europeans had lacked naval periority, they could have defended both aces from invasion by land or sea. China d always insisted that barbarians of any ipe carry out their trade and then leave,

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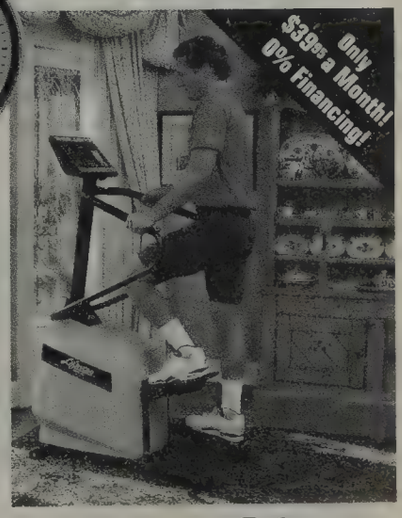
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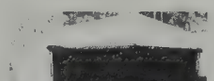
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but instead of acting as temporary visitors, the Western traders were staying longer and longer, becoming in effect permanent residents.

Another major grievance was that the foreigners would not submit to Chinese laws when in China. Some European sailors murdered Chinese citizens, but their leaders would not turn over the culprits to the Chinese magistrates. Lin's research revealed that foreigners in England were required to obey British law, but when he confronted the British commanders with this double standard, they merely conceded that he had a case and again refused to turn over British subjects to almost certain execution. Other European and American traders acted similarly.

Despite the barbarian offenses, Lin preferred negotiation and reasoned discussion to fighting a battle that he felt would be difficult to win. In a final, carefully worded letter to Queen Victoria, he wrote:

Let us suppose that foreigners came from another country, and brought opium into England, and seduced the people of yo country to smoke it. Would not you, the so ereign of the said country, look upon such procedure with anger, and in your just i dignation endeavor to get rid of it? Now w have always heard that Your Highness po sesses a most kind and benevolent hea Surely then you are incapable of doing causing to be done unto another that whi you should not wish another to do unto yo [Chang Hsin-pao, *Commissioner Lin a the Opium War*]

Moral persuasion has not, historicall proved very effective in dealing with dru smuggling or rulers who sanction it. Unc ficially, the contents of the letter we probably widely known but, as with h previous attempts, Lin received no offici response. Britain was determined that th opium trade would continue, by force necessary, and because China had bee unwilling to open formal diplomatic cha nels, the British government would not a cept a letter to the queen from a commi sioner.

Lin's efforts to rein in the barbaria



Chinese opium smokers, circa 1870
Hulton Deutsch Collection, London

subdue the Chinese appetite for opium
e ultimately unsuccessful, and the em-
or harshly accused him of failing:

ernally you wanted to stop the trade, but
as not been stopped. Internally you
ted to wipe out the outlaws, but they are
cleared away.... You are just making ex-
s with empty words. Nothing has been
mplished but many troubles have been
ted. Thinking of these things I cannot
tain my rage. What do you have to say
?

Lin replied that the Chinese should ad-
ss the threat and fight the British,
ing back to the interior and fighting a
rrilla war if necessary. He warned the
peror not to attempt to placate the
ish: "The more they get the more they
nand, and if we do not overcome them
force of arms there will be no end to our
bles. Moreover there is every proba-
ty that if the English are not dealt with,
er foreigners will soon begin to copy
even outdo them."

n June of 1839, Lin had 20,000 chests
pium destroyed in Canton, and the for-
n merchants fell back to Macao. The
tish sent a fleet of their most powerful
rships on a punitive expedition, and
y overwhelmed the Chinese fleet when-
r they faced it. Among their warships
re the "ships-of-the-line," massively
ed vessels that demonstrated the ad-
tage of superior technology over supe-
numbers in modern warfare. In the
mmer of 1842, China was forced to sign
humiliating Treaty of Nanking, which
quired $21 million in reparations,
ened five ports to British trade (includ-
Canton and Shanghai), and ceded
ng Kong, surrounding islands, and part
the mainland to Queen Victoria. China
o agreed that future Chinese–
tish relations would be on terms of
mplete equality." This condition seems
nic, because the terms of the treaty were
tainly in the Western merchants' favor.
is wording was insisted upon by the
itish, however, because previously
ina had dealt with Westerners as bar-
ian traders, never recognizing them as
icial representatives of foreign govern-
nts. Nowhere did the treaty mention
ium, but everyone knew that the drug
d been at the heart of the war.

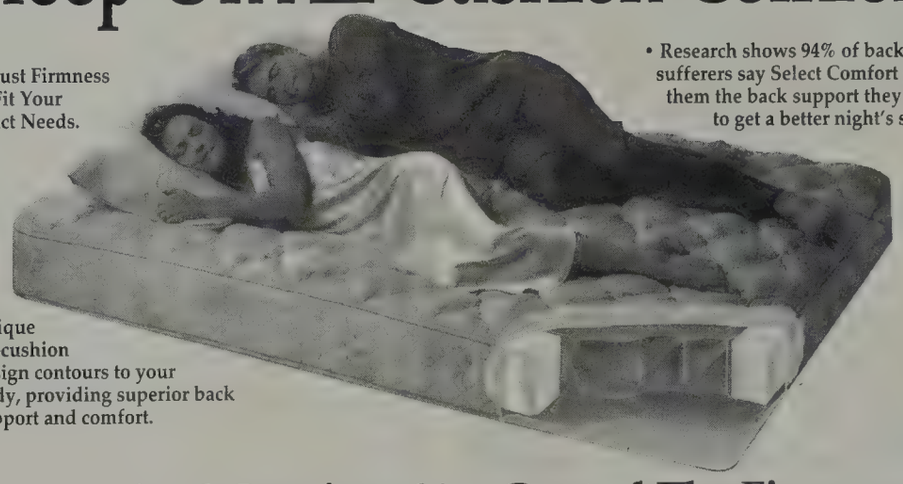
One hundred fifty years later, China still
ls the sting of this defeat. The recently
gotiated treaty for the return of Hong
ng in 1997 is viewed as just a fraction
the restitution owed. In 1990, writing in
Beijing Review, historian Hu Sheng,
sident of the Chinese Academy of So-
cial Sciences, lamented the cost of the war in terms of Chinese health, hard currency, and national honor. He also observed that for the next hundred years China was under continuous attack by the West and Japan, but because the emperors were willing to tolerate their presence, the people were unable to rise up and throw out the foreigners. In his view, and in that of many Chinese, "Only the Chinese Communist Party could do this."

For his failure to curb the barbarians, Lin Zexu was demoted and disgraced, and spent the last few years before his death supervising irrigation projects and the repair of dikes. In retrospect, he is regarded as a hero. "The Chinese army, commanded by Lin," writes Hu, "resisted the invaders together with the local people. However, the corrupt Qing court was unable to continue the resistance and succumbed to the invaders."

Commissioner Lin would no doubt feel vindicated, and perhaps even take some pleasure in the way many Western nations are now on the receiving end of the drug policies they helped invent.

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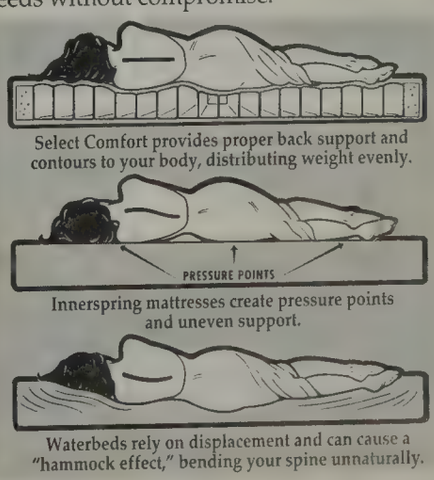
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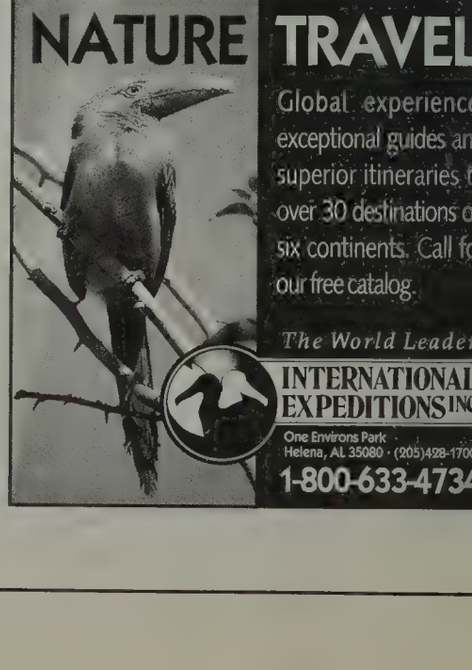


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Origami Holiday Tree

Marking the start of the holiday season, the Museum's twenty-first annual origami tree goes on display Friday, November 19, in the Roosevelt Memorial Hall. More than 2,000 folded-paper animals, created and donated by origami enthusiasts from around the world, will decorate the fifteen-foot tree. Three thousand silver-paper stars provide the tree with a glittering halo, and around the tree's base, the four seasons are represented in habitat dioramas. The tree can be seen through Sunday, January 9.

The Fabergé Collection

A third-generation Russian of French descent, Peter Carl Fabergé (1846–1920) was an internationally renowned goldsmith, jeweler, and designer of unusual jewelry and other luxury items, including ornamental Easter eggs created for the last two czars. On Tuesday, November 23 at 7:00 P.M., Mary Ellen Sinko, curator of the Fabergé collection in the Forbes Magazine Galleries in New York City, will give an illustrated lecture in the Kaufmann Theater on the collection's beginnings and the history of the House of Fabergé. For further information, call (212) 769-5606.

Gorillas in the Mist

Until she was murdered in 1985, Dian Fossey had spent two decades among Rwanda's mountain gorillas, observing and documenting their behavior. Wildlife biologist, photographer, and writer Ian Redmond was Fossey's research assistant for two years at the Karisoke Research Centre in the Virunga Volcanoes region of Rwanda. He will talk about his work with Fossey and the impact of her long-term gorilla research on the region on Tuesday, November 30, at 7:00 P.M. in the Main Auditorium. For more information, call (212) 769-5606.

Our Ecological Past

Definitive evidence of humans first appears in the archeological record about 40,000 years ago, and since that time, various civilizations have left their marks on the environment. Jared M. Diamond, professor of physiology at the University of California at Los Angeles Medical School and frequent contributor to *Natural History,* will talk about human ecological history on Tuesday, November 2, and Thursday, November 4, at 7:00 P.M. in the Kaufmann Theater. Admission for both lectures is $20.

Behind the Sacred Mask

Anthropologist Peter Gold, of San Francisco's California Institute of Integral Studies, will lecture on the meaning and ritual use of sacred masks from various cultures, including Upik Inuit shamans' vision masks, the kachina ritual masks of the Hopi and Pueblo Indians, and the masked pantheon and rites of Tibetan religions. The lectures will be given on consecutive Tuesdays, November 9 and 16, at 7:00 P.M. in the Kaufmann Theater.

Dance Cultures of Three Continents

Under the stage name "Morocco," Carolina Varga Cinicu directs her own dance company. Her three decades of research on the dance, music, and dress of North Africa, the Middle East, the Mediterranean, and the Caucasus will be the subject of illustrated lectures for four consecutive Monday evenings, beginning October 18 and ending November 8. The lectures will begin at 7:00 P.M. in the Kaufmann Theater, and tickets for the series are $35.

Predators, Prey, and Their Habitats

For more than twenty years, wildlife expert Andrew Simmons has been introducing live predators to Museum audiences. He returns this year for four consecutive weekends, October 23–24 through November 13–14, appearing at 11:00 A.M. and 1:0 P.M. in the Kaufmann Theater. Tickets fo each program are $10 ($7 for students an children).

Minerals, Myths, and Magic

Human fascination with gems and jew elry throughout human history will be th subject of three Tuesday-evening talks be ginning November 9. Joseph J. Peters, se nior scientific assistant in the Departmen of Mineral Sciences, will discuss Cro Magnon jewelry, alchemy's origins in Al exandria, and ancient myths about Chi nese jade. The lectures begin at 7:00 P.M



A jadeite carving of Quan-Yin, Chinese goddess of mercy, is featured in the "Minerals, Myths, and Magic" lectures.
Harold and Erica Van Pelt

e Kaufmann Theater, and series tick-
re $30.
n Friday, November 19, and Monday,
ember 22, Peters will lead a tour of the
Morgan Memorial Hall of Gems be-
ing at 7:00 P.M. A ticket for both tours
s $15.

THE PLANETARIUM

he latest scientific findings from the
ting Hubble Space Telescope and the
oming rescue mission to correct its
functions will be discussed by Stephen
aran, senior staff scientist in the Labo-
ry for Astronomy and Solar Physics at
SA's Goddard Space Flight Center in
enbelt, Maryland. The slide-illustrated
ure, part of the "Frontiers in Astron-
and Astrophysics" series, will take
e on Tuesday, November 16, at 7:30
in the Sky Theater. Tickets are $8 ($6
members).
he Planetarium's holiday story, "Star
Christmas," will show the skies the
e Men saw when they were traveling
ethlehem nearly 2,000 years ago. The
w will begin on Wednesday, November
and run through Sunday, January 2.
information about prices, show sched-
, and other Planetarium events, call
2) 769-5900.

OBAL CULTURES IN A
ANGING WORLD

As part of the Museum's year-long cele-
ion of cultures in a changing world, the
ucation Department will present free
ures and performances throughout the
nth. The programs include a lecture and
performance of rap music forms; a
cert of Chilean music by Grupo Con-
sso; and the drama, music, and dance of
e Valle Parreno, Montego Joe and
npany. For a complete program sched-
call (212) 769-5315.

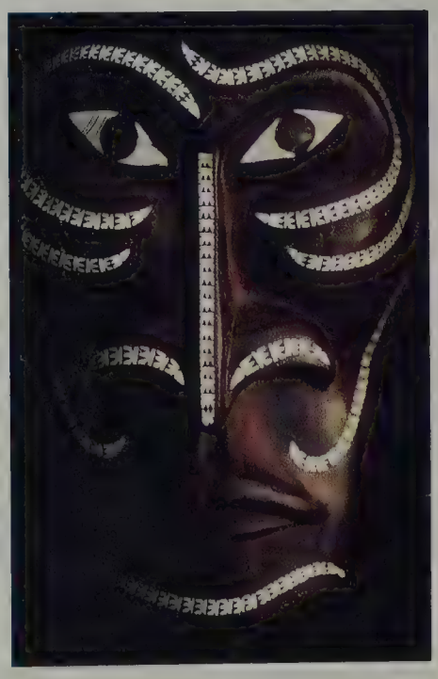
ese events take place at the American
seum of Natural History, Central Park
st at 79th Street in New York City. The
ufmann Theater is located in the
arles A. Dana Education Wing. The
seum has a pay-what-you-wish admis-
n policy. For a complete schedule of fall
ures, call (212) 769-5310. For more in-
mation about the Museum, call (212)
-5100.

MYTHS AND REALITIES OF POLYNESIA

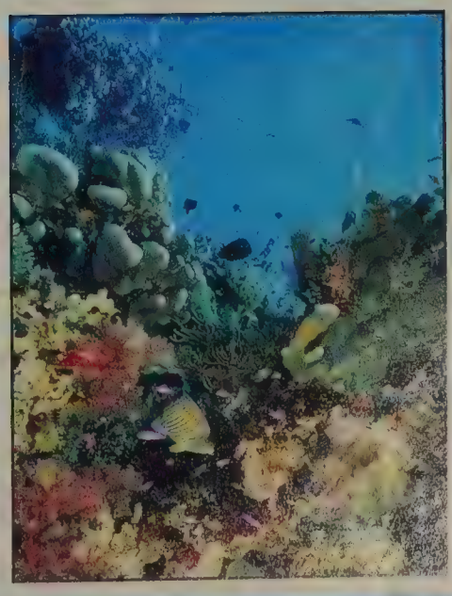
Tahiti, Marquesas and Tuamotus
April 1-12, 1994

Remote, serenely beautiful and rich in tradition, the islands of Polynesia have for centuries been a welcome haven for foreign explorers, writers, artists and adventurers. Join the American Museum of Natural History this spring as we follow in the wake of Captain Cook, Captain Bligh, Gauguin, Melville, R.L. Stevenson and many others among the natural and cultural treasures of Polynesia.





During this voyage we will explore legendary Tahiti and two dramatically different island chains: the rugged, volcanic Marquesas and the low-lying coral atolls of the Tuamotus. A team of lecturers accompanies us throughout to discuss Polynesian art and culture, as well as the way Polynesia has been depicted by visiting artists and authors. Join us for this exciting tropical adventure.



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Thanksgiving's Lunar Eclipse

by Joe Rao

During the late-night hours of Sunday, November 28, as America's Thanksgiving weekend comes to a close, the bright full moon will transform into a mottled, coppery globe, caught for a while in the long, tapering shadow cone cast into space by Earth. For the entire Western Hemisphere, as well as a large part of Europe, this will be an excellent opportunity to observe a total eclipse of the moon. The action takes place about midnight as seen from eastern North America, and earlier in the evening for skywatchers in the west. The moon will be high in the sky in the constellation Taurus.

While a total eclipse of the sun can be seen only by those within a narrow path on the earth's surface, an eclipse of the moon is a more global experience. It is visible anywhere the moon is visible, from an entire hemisphere. Given clear skies, nearly two billion people will be able to enjoy this year's spectacle.

The eclipse begins as the moon enters the penumbra, the pale outer portion of the earth's shadow, at 10:27 P.M., EST (add or subtract the appropriate number of hours for other time zones). No change in the moon's appearance will be visible, however, until about thirty-five minutes later when more than half of the moon has become immersed in this outer shadow, causing its upper left edge to appear shaded. For the next thirty-five minutes, the shading will spread and deepen.

The pace will quicken when the moon's edge first contacts the dark, circular edge of the earth's umbral shadow (11:40 P.M., EST). The umbra is much darker than the penumbra and fairly sharp edged, so it produces a dramatic change. Within minutes the moon will look as though a bite has been taken out of its left-hand edge. The bite will grow steadily larger as the umbra creeps across the lunar disk.

When the moon becomes completely enveloped in the umbra (1:02 A.M., EST), the total eclipse begins. The period of totality will last for a relatively brief forty-eight minutes, somewhat less than the average of seventy-three minutes for a typical total lunar eclipse. "Nevertheless," notes NASA astronomer Fred Espenak, "this is still seven times longer than the maximum duration of the great solar eclipse of 1991." And unlike an eclipse of the sun, a lunar eclipse is perfectly safe to view. All you will need to watch this phenomenon are your eyes, but binoculars or a telescope will give a much nicer view.

During totality, observers beyond the city lights will notice many more stars than were visible earlier in the night, because the brilliant late-autumn full moon floods the sky with light and greatly reduces the number of naked-eye stars. Even before totality, the sky should be dark enough to see the Milky Way. For those watching from a rural location, the landscape will take on a somber aspect as the eclipse progresses. Before the eclipse, the moon will look flat and one-dimensional, but during totality it will take on a three dimensional appearance—like an illuminated ball suspended in space.

In the earlier stages of the eclipse, the earth's shadow seems quite black. But as more of the moon is covered, any colors present within the shadow will become noticeable. The earth's shadow projected on the moon is usually a coppery red, from sunlight that passes close to the earth and is bent by our atmosphere into the shadow. Just a few minutes before and a few minutes after totality, the contrast between the remaining pale-yellow sliver and the ruddy color spread over the rest of the disk may produce a beautiful phenomenon known as the "Japanese lantern effect."

But a word of caution: the appearance of the moon varies considerably from one eclipse to another. In recent years, the June 1991 eruption of Mount Pinatubo in the Philippines has had a large effect on the darkness and color of lunar eclipses. T volcano blew sulfuric acid mist and fi particles of volcanic ash—known colle tively to scientists as aerosols—into c planet's stratosphere. During the to lunar eclipse last December 9, this v canic haze blocked most of the reddi light that would have normally filter around the edge of the earth to illumina the moon, and as a consequence, the mo almost completely disappeared fro view! During the past year, howeve much of Pinatubo's aerosol cloud has d sipated, so (barring any other significa volcanic eruptions between now and N vember 28) the upcoming eclipse shou be brighter and more colorful than last D cember's event.

Near the middle of the upcomi eclipse, the upper portion of the mo should appear darkest, since it will passing closest to the center of the earth shadow. Totality ends when the easte (left) edge of the moon begins to emer from the shadow (1:50 A.M., EST). The the sequence of eclipse phenomena occu in reverse order.

The next lunar eclipse visible to Nor Americans will be on May 24–25, 199 when about one-quarter of the moon's di will slide through the earth's shadow. 1996, two total eclipses will occur. Th first, on April 3, will be visible only fro the eastern half of North America, whi the second, on September 26, will be vi ible over the entire continent.

THE PLANETS IN NOVEMBER

Mercury passes inferior conjunctio on the 5th and, in a feeble manner, a tempts to eclipse the sun. Called a transi this event is a relatively rare occurrenc On the average, there are thirteen transi of Mercury each century. Unfortunatel the one this month will not be visible fro North America. About ten days late you'll find Mercury is a relatively brigh

ICEBREAKER EXPEDITION TO THE NORTH POLE

July 12-31, 1994

The North Pole, surrounded by more than 500 miles of drifting pack ice, has long been a coveted prize for explorers. Conquered only within this century, it continues to add names to an already illustrious list of explorers, among them Peary, Amundsen, Ellsworth and Nansen. The American Museum of Natural History invites you to join a team of museum scientists for a once-in-a-lifetime opportunity to cross the polar ice cap and stand at 90 degrees north. Sailing aboard a powerful Russian icebreaker, we will travel safely and comfortably to the North Pole, avoiding the extreme hardships faced by previous adventurers who had to travel overland and aboard ships ill-equipped for the ice. Along the way, we will search for walrus, seals, seabirds, whales, polar bears and other Arctic wildlife. We will also explore Franz Josef Land, a remote Russian archipelago where early Arctic expeditions wintered, and Norway's wildlife-rich East Spitsbergen. Join us for an unforgettable adventure.





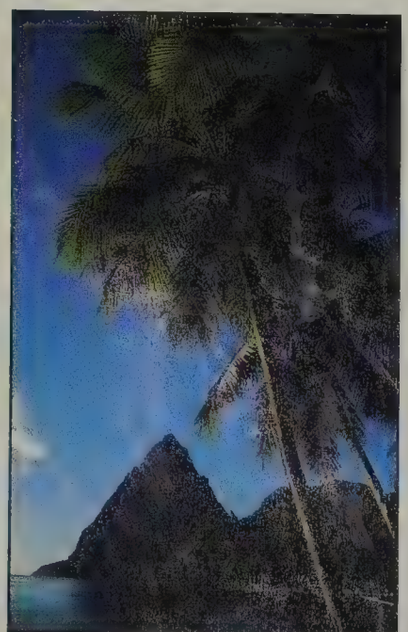
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starlike object, appearing very low in
southeast about an hour before sun
(see Venus below). It will be at its grea
angular distance to the west of the sun
the 22nd.

Venus continues to be visible low in
southeast, rising about one to one an
half hours before the sun. During the m
day hours on the 8th, it will pass 0.4° no
of Jupiter. As a result, skywatchers
see the somewhat dimmer Jupiter j
below and to the right of Venus before s
rise on the 8th and just above and to
right before sunrise on the 9th. A t
crescent moon will be near this eye-cat
ing planetary duo on the morning of
12th. On the morning of the 14th, Ve
can be used as a guide to find Mercu
which is less than a degree away.

Mars is impossible to see this month

Jupiter emerges from the bright mo
ing twilight at the start of the month, a
as the month progresses, the planet is
ible higher and higher in the southeast
sunrise. Mercury, Venus, and Jupiter
form a conspicuous grouping in the mo
ing sky at midmonth, along with the bri
star Spica in Virgo.

Saturn, in Capricornus, is near t
meridian at nightfall, setting about 12
A.M. on the 1st and about two hours earl
by month's end. It is the yellowish "st
well below the fat crescent moon on t
evening of the 20th.

Uranus and **Neptune** remain near ea
other in Sagittarius.

The **Moon** reaches last quarter on t
7th at 1:36 A.M., EST; is new on the 13th
4:34 P.M., EST; reaches first quarter on t
20th at 9:03 P.M., EST; and will be full
the 29th at 1:31 A.M., EST.

The Leonid Meteor Shower is due
peak on the morning of the 17th. This
the famous display that, at approximate
thirty-three-year intervals, brings the p
tential of a stupendous "storm" of me
ors. Since the particles producing t
Leonids evolved from the comet Temp
Tuttle, and this comet is due to return
the sun's vicinity early in 1998, there
hope that a sensational meteoric displ
will materialize before the end of this de
ade. The Leonids have already show
signs of "perking up" and indeed, y
might see about fifteen meteors per ho
emanating from the sickle of Leo, which
high toward the southeast by dawn.

*Joe Rao, an associate astronomer at t
Amercan Museum's Hayden Planetariu
is filling in for Gail S. Cleere, who will
turn next month.*

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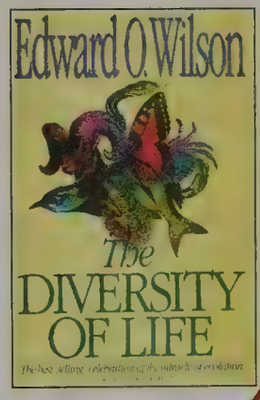


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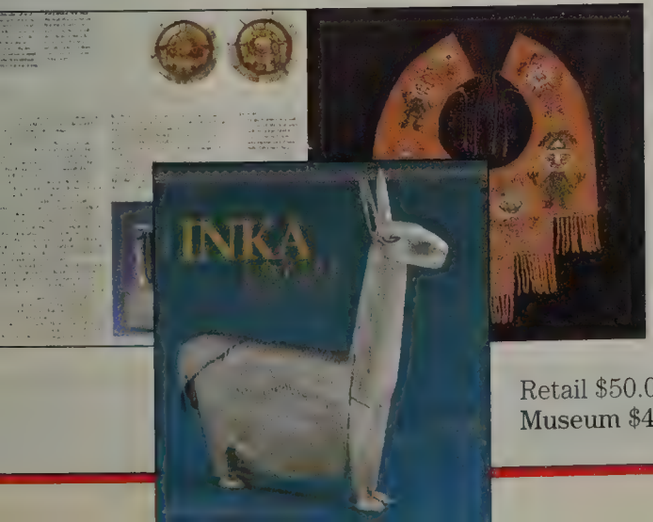
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A Cheddar Aesthetic

Cheese judging, like wine tasting, requires a fine palate and an arsenal of technical jargon

by Raymond Sokolov

My plane to Burlington, Vermont, landed just minutes before a pelting, thundering lightning storm flooded roads and cut off power to the Shelburne Inn on the nearby shore of Lake Champlain. (My arrival in a faraway place has often brought natural disasters to the area. California's two major earthquakes in the last twenty-five years each occurred less than a day after I touched down in the Golden State. Departures, too. An hour or so after I left York, England, in 1984, the city's ancient cathedral went up in flames.)

The Vermont storm immobilized me on a highway for an hour or so, but it left me unharmed and certainly did no real damage to Shelburne, a monumental estate built to endure much worse than a raging tempest. Shelburne is a relic of pre-income-tax Vanderbilt wealth, and it is still a working farm of great size and beauty, with huge barns that fall somewhere between shingled cottages and turreted castles. Shelburne is essentially a dairy farm and produces a venerated cheddar.

Cheese was the connection that led me and dozens of other tyrophiles and tyropolists (cheese lovers and cheese business folk) to the property for several days in August for the annual meeting of the American Cheese Society (ACS). Like Shelburne, the ACS is a (relatively) harmonious amalgamation of great and humble aspirations and styles. Among its members are big-time cheese producers and family farmsteads with modest flocks of cows, goats, or sheep. Some conferees were just learning to separate curds from whey; others were taking time off from antiseptic dairies where all workers wear white hairnets, and men, if they are not cleanshaven, wear beardnets.

There were cheese brokers and cheese whizzes in the export–import game. At one session, Alyce Birchenough explained, in intimidatingly effortless detail, how she and her husband alone farm sixty acres near Mobile, Alabama, prosper with dairy cattle, and sell all their cheese from their little home shop. Next came Miles Cahn, who described how he sold his successful leather goods firm (Coach Bag) and invested in what has become one of America's largest producers of goat cheese, Coach Farm.

Cahn's talk was full of good humor and many jokes—on himself, his wife, Lillian, and their goats. He concluded by advising the crowd gathered in a converted coach barn that Coach Farm was an example of how it was possible to make a small fortune in goat cheese—as long as you were willing to spend a large fortune to do it.

Among such experts, I was out of place. Next to, for example, the Welsh dairy consultant Eurwen (pronounced Eye-er-wen) Richards, I felt like a complete cheeese baby. But the ACS management had paired the two of us as a team in its annual cheese judging. Richards was the technical judge; I was the aesthetic judge. This division is meant, so far as I could determine, to give voice to the professional dairy world, as well as to the educated consumer. In practice, the technical judges usually sway the aesthetic judges with their far greater fund of knowledge and experience in the actual manufacture and supervision of cheese making. The technical people also tend to have definite ideas about what a particular kind of cheese should be like, and they have an impressive jargon for expressing their opinions.

Richards is outstandingly fitted out with such skills. She has a degree in dairy s
ence and has spent her life supervis
professional dairies and retail purchas
programs. When I met her, she had j
flown in from a national cheese event
Britain, where a rumored one thousa
cheeses had passed through her han
Soon after we were introduced, she put
her white dairy uniform and took out
knives.

"I always declare my profession whe
travel," she confided cheerfully, displa
ing a thin, longish jackknife and a set
tools that looked something like apple c
ers. Each instrument consists of a hand
a fluted metal shaft, and a semicylindri
business end. To be precise, the busin
end is a very sharp, almost closed cir
that gets pushed straight into a chee
then rotated. When the judge pulls the t
out, it brings with it a small tube of chee
lodged in the fluted shaft. The judge
cheese grader in a dairy) then can see wh
the cheese is like in its innermost p
without cutting up a whole cheese. S
can also knead the cheese, smell it, a
taste it. And if she works on the part of t
cheese cylinder that came from farthest
side the cheese, she will have enough of
untampered-with cylinder to put it back
the hole she made, smooth out the surfa
and leave it so that no one will know wh
has happened. In professional grading s
uations, this allows the diary to sell t
cheese after it has been tested.

Richards lent me one of these tools, a
I immediately made the classic blunder
pushed it in and then pulled it out, forg
ting the rotation. Ergo, I got no cheese, ju
left a barely perceptible circle on its su
face. Soon, however, I was extracti
cheese cores with aplomb, sniffing, rolli

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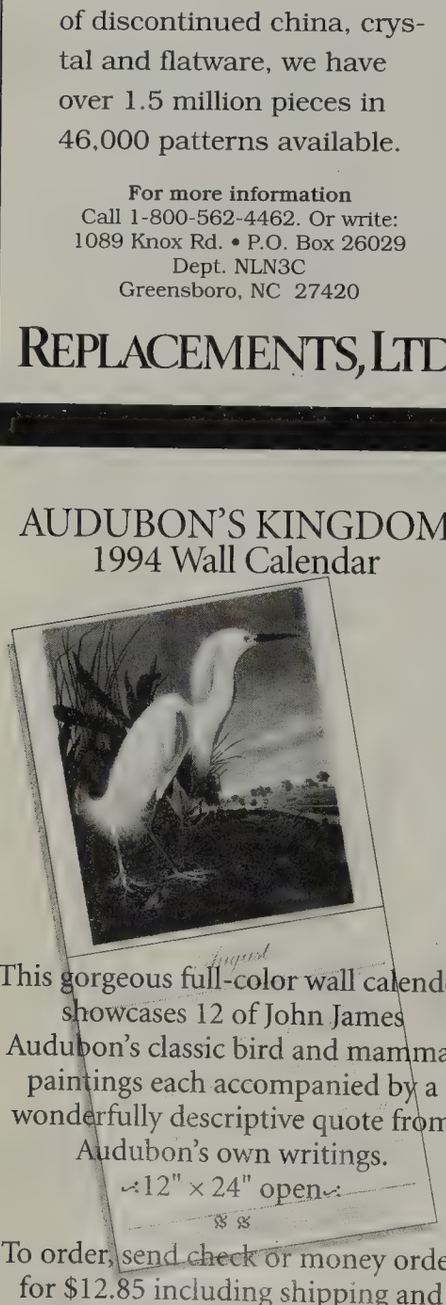
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bits between my fingers, bending the cores back on themselves, and generally acting like a cheese grader, if not altogether feeling like one.

As our first, and most interesting, assignment, Richards and I worked our way through a table of cheddars. They came in many shapes and sizes, from behemoth to cute. Some were pale white; some were colored orange by annatto. They were not identified as to their source, but it was clear from the cosmetic diversity and the presentation (from industrial to sloppy) that we were tasting a gamut ranging from utterly commercial to post-sixties dropout cheeses.

For Richards there was the additional problem of bridging the gap between the cheddars she knew from home and the American-style cheddars on the table before us in the Shelburne barn. She was aware of this problem as we started—and was determined not to apply a foreign standard to the cheddars we were to judge. In practice, this was very difficult, especially at the beginning. American cheddars struck her, by and large, as excessively acid and lacking in complexity. "Unbalanced" was a word she used a lot.

From my end of the table, I could sympathize with her reactions. We were tasting the same cheeses and, for the most part, we detected the same flavors and textures. It took only a few minutes of discussion to establish a common vocabulary. And I was soon relieved to see that the basic job of assessing cheddars was not beyond me.

It wasn't so difficult because, as I quickly realized, I had been doing it consciously all my life. But this was an ganized tasting, and like all such sens comparisons, it instantly established in mind a much more exact set of crite about the taste and texture than my pre ous, inchoate attempts with one or t cheeses at a time had been able to achie A professional like Richards has the ad tional advantage of knowing and be able to work with a small lexicon of co words that fit the essential categorie cheese taster will encounter again a again.

Wine tasters operate in a similar w Outsiders who hear tasters talking amo themselves or read a professional acco of a wine often make the mistake of d missing the jargon as a hopelessly pret tious and subjective verbal front meant dazzle the public. The reverse is true. A parently silly terms like "violet" "fruity" will convey an exact form of se sory experience to someone who has be taught to connect these words to speci events on the tongue or in the nose.

The power of these professional tas word codes is so great that, once one u derstands them even partly, they quick take over the way one thinks about flav and aroma. The ability to tag a taste o component of a complex taste reliab with a name that others will also apply, liably, is a satisfying skill. For professio tasters, it is absolutely essential.

If you want to see what I mean, try th simple experiment. Buy three or fo kinds of cola. Have someone else po them into identical glasses (the glass

Polenta with Fennel and Tomato-Cheese Sauce

4 cups milk
4 cups water
2 cups yellow cornmeal
Salt and pepper
3 bulbs fennel, trimmed and sliced
Oil
1 large onion, peeled and chopped
1 cup chicken stock
3 cups tomato purée
3 cloves garlic, minced
½ cup yogurt
¼ pound Gorgonzola cheese

1. Bring 3 cups milk and 3 cups water to a boil in an ovenproof pan. Reduce to a simmer.
2. Stir cornmeal into the remaining cup of cold milk and add 1 cup cold water. Add salt and pepper. Then pour mixture into simmering milk-water mixture and stir until very thick. Paint the top with oil to prevent formation of a skin and reserve in a warm oven.
3. Sauté the fennel slices in oil until lightly browned. Add onion and continue sautéing until translucent. Add chicken stock, tomato purée, and garlic. Return to a simmer and continue cooking for a few more minutes until fennel is softened. (You may want to stop sooner, when the fennel still has some crunch left in it.)
4. Off heat, stir in yogurt and Gorgonzola. When the cheese has melted into the sauce, bring to the table in a serving dish. Serve the reserved polenta on individual plates and then distribute the fennel-cheese-tomato mixture over it.

Yield: Four to six servings

to be marked secretly, say with a bered label at the bottom of the stem, the person running the test has to be to identify which cola was poured into ch glass). I pick cola because most ple will have had a lifetime of uncon- us tasting experience, and many peo- will be able to effect a perfect set of dfold identifications the first time out. ainly, the difference between the vari- brands and varieties should be blind- y obvious from the start, and if the or- zer reveals the brand names, a few nents of concentrated retasting should e it a simple matter to identify all of n in a repeat of the first blind testing.

Vine and cheese are more complex e phenomena than colas, but profes- al tasters achieve mastery over them nuch the same way. They taste, and learn to associate key words with t they have just experienced. The e they do it, the greater the refinement neir taste categories, both sensory and bal. The reliable and objective connec- between the two is what lies at the t of serious tasting.

No wonder, then, that amateurs—even, erhaps especially, those with broad in- nal experience of wine or cheese—fall pily in line behind professional tasters, n their easy and convenient command echnical vocabulary and the system of rimination it represents.

As it happened, Richards was actually e restrained in her use of dairy jargon. d while it is true that we agreed a very n percentage of the time, I made a seri- effort to voice my opinion, in as pre- a way as my sensory-verbal skills per- ted, before she did. And we still eed, although I doubt that she was ever ved into agreement by the force of my nion.

n any case, the most remarkable aspect our agreement, to my mind, was that we nd so many of the cheeses to have vir- lly the same taste. Richards didn't like taste, and in trying to understand why, egan to see what she meant about lack balance and excessive acidity. But it o occurred to me that Richards was ly-nilly applying a British standard to nerican cheese. The taste profile we t encountering—and which she found leasant—was the flavor familiar to me m a lifetime of buying cheddar in coun- stores. It was the flavor of those pic- esque blocks of cheddar known oughout New England as "store," or t," cheese.

That flavor, I was rapidly coming to see, which would strike the unhabituated palate as aggressive and verging on down- right unpleasant, was what American cheddar initiates call sharp and what they associate with rural America, pure as the driven snow. Evidently, the cheddar world in this country has aimed at this favored flavor. And by the evidence of our ACS tasting, most cheddar makers have suc- ceeded in producing that dramatic, which is to say unsubtle, taste.

One manufacturer, however, squared the circle, by making a cheddar whose basic flavor silhouette coincided with the sharper image of the mainstream product but which also offered a complex subtext of other tastes. Richards and I agreed about this and made the cheese our win- ner. It was Washington State University's Cougar Gold.

In case my internist reads this, I want her to know that I followed Richards's lead in a way that had nothing to do with judg- ing cheese, but everything to do with sur- viving a potential cholesterol implosion. I used a spittoon.

Raymond Sokolov is a writer whose spe- cial interests are the history and prepara- tion of food.

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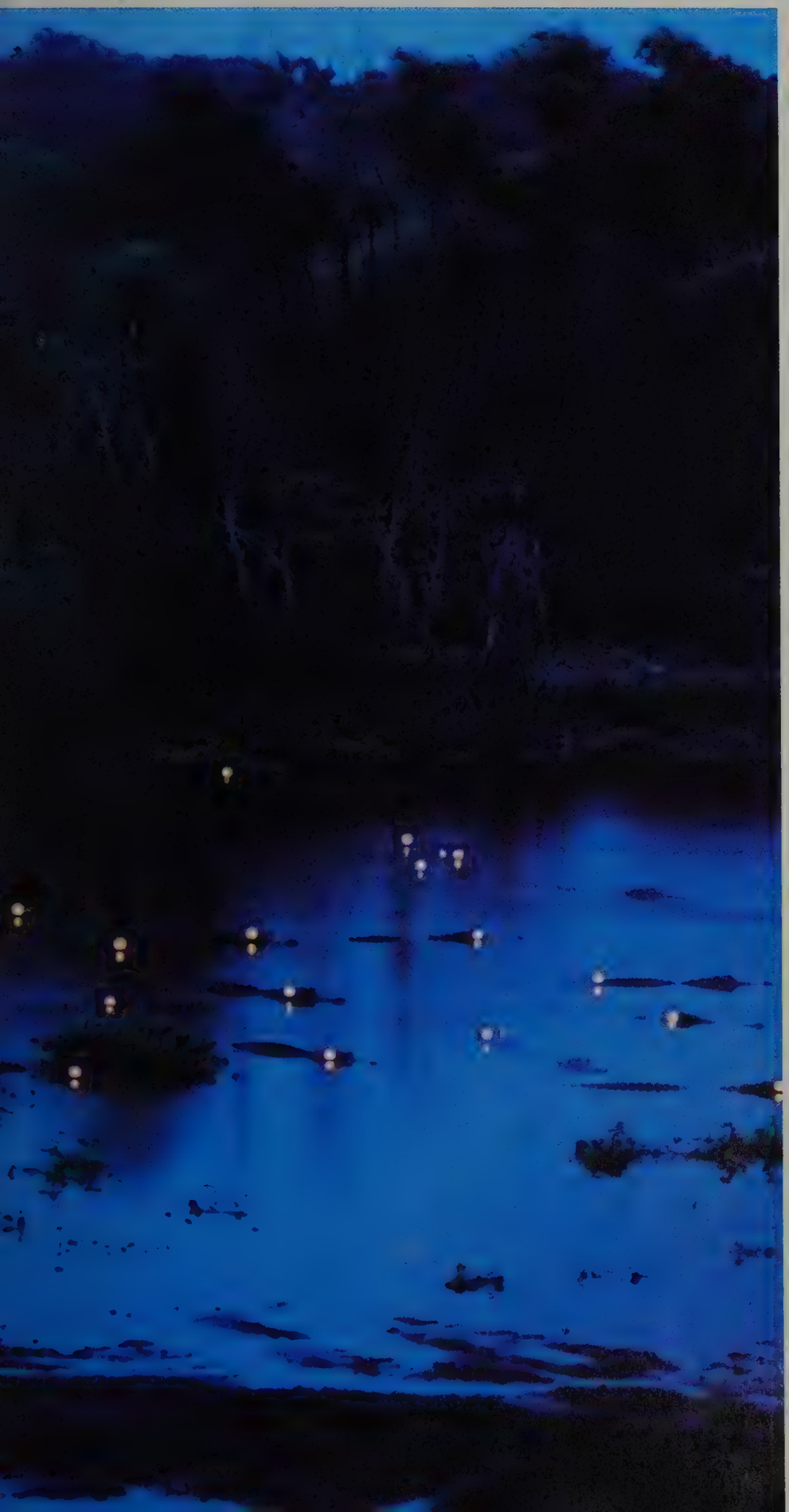
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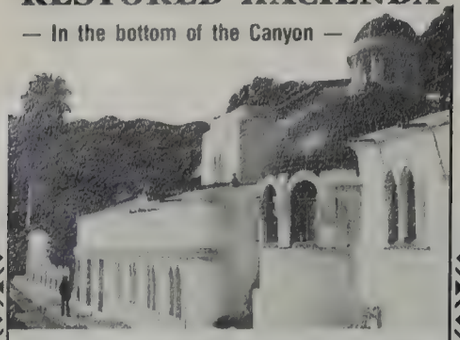
How many alligators does it take to fill a Florida sinkhole? During a twilight visit to this one at Paynes Prairie State Preserve, south of Gainesville, the photographer counted 212 pairs of eyes shining back at him—although only about 40 are visible in this photo. By May 1990, after a year and a half of drought, most of the preserve's wetlands had dried up, forcing the alligators to congregate in this remaining deep pool.

According to Kent Vliet, a herpetologist at the University of Florida, such severe crowding is more than an inconvenience. Cannibalism is not uncommon among alligators, with adults occasionally consuming the younger reptiles. In wetter times, the immature alligators can avoid contact with their rapacious elders by occupying shallow pools away from the deep sinkholes. During this drought, however, the dwindling water forced them to live packed together with the older alligators, often with dire consequences; within fifteen minutes, Vliet saw adults attack and devour two subadults at this site. The victims were four to five feet in length.

The glow of the alligators' eyes is caused by light from the camera's flash reflecting off a thin, crystalline layer behind their retinas. In alligators and many other nocturnal animals, these mirrorlike surfaces enhance the animals' vision in dim light. After striking the retinas once, light is reflected off the back of the eyes so that the retinas register the light twice, effectively doubling the eyes' sensitivity. All the better to see who's next to you in a crowded pond—*R. A.*

Photograph by John Moran
UNEP–Select

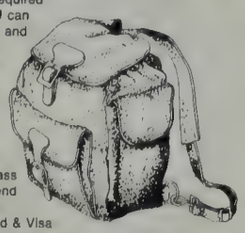
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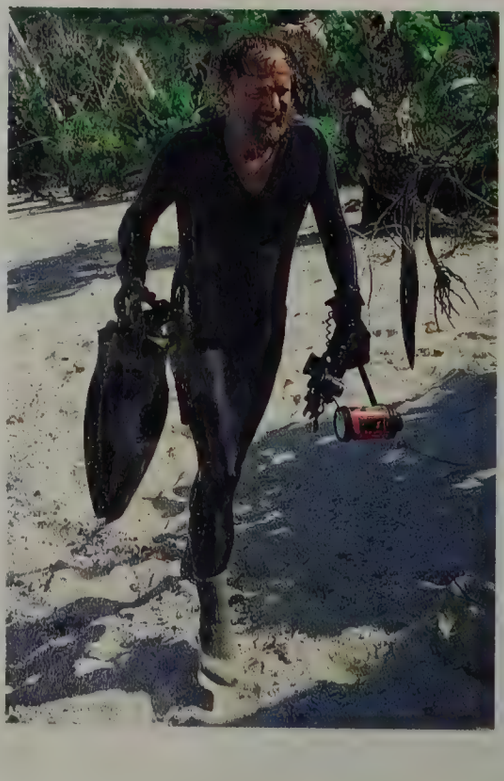


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AUTHORS



William H. Karasov (page 32) has been interested in nature ever since his Saint Paul, Minnesota, boyhood, when he was inclined to take long hikes along the Mississippi River. Now an associate professor of wildlife ecology at the University of Wisconsin at Madison, Karasov has spent several years studying modulation of animal digestive systems. He started out with laboratory animals (mainly mice), but the ecologist in him quickly took over, and he began to investigate the role of such changes in wild animals, such as the migratory wrens and robins that are the subjects of his article. The quest for digestive truth has even taken him to Australia, where he investigated how rainbow lorikeets digest the sugar in nectar. Among Karasov's current projects are the further study of avian nutrition, with special emphasis on the ruffed grouse, and an assessment of the effects of environmental toxins on Wisconsin's bald eagles. In his spare time, Karasov loves to read (both fiction and nonfiction), watch birds, cook, and go camping with his wife and two young daughters.



Trained as both a diver and an archeol gist, **Daniel J. Lenihan** (page 40) is chi of the National Park Service's Submerge Cultural Resources Unit. "In plain En lish," he explains, "this means I serve their chief maritime archeologist and lea the only team of underwater archeologis in the federal government." Lenihan's fir assignment was to examine the impact national reservoirs on archeological site More recently his team mapped and pho tographed various American, Germa and Japanese ships sunk in the 194 atomic bomb testing at Bikini Atoll. Fo additional reading he recommends *Th Hidden Canyon: A River Journey,* by Joh Blaustein and Edward Abbey (New Yor Penguin Books, 1977) and *Cadilla Desert: The American West and Its Disap pearing Water,* by Marc P. Reisner (Ne York: Penguin Books, 1987).

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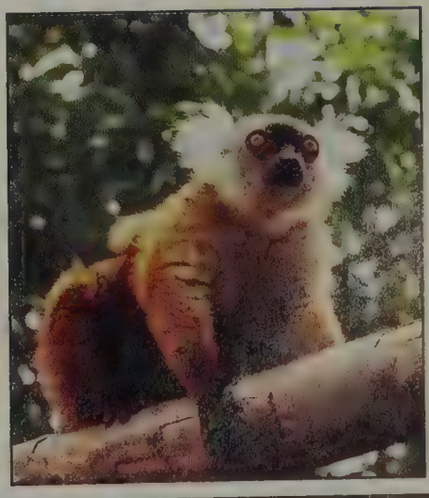
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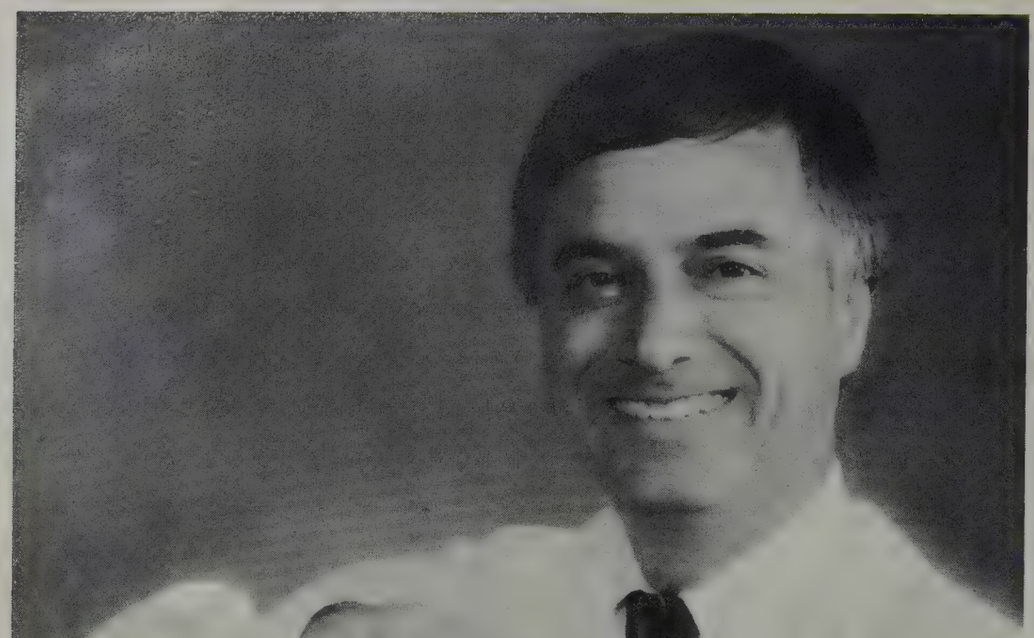
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Harry Y. McSween, Jr. (page 6 holds a globe of Mars, the focus of planetary research. After earning his M in geology from the University of Geo in 1969, McSween completed a five-y stint as an Air Force pilot. Flying transp planes soon became routine, however, he resumed his study of geology, receiv his Ph. D. from Harvard in 1977. He t moved to the University of Tenness where he is now a professor and head the Department of Geological Scienc McSween began his research with me orites (and their parent asteroids), but a proposing that some pieces of Mars h been blasted into space by meteorite i pacts, he extended his interests to the planet. As a member of a NASA te hoping to answer geological questio about Mars, he is mourning the loss of *Mars Observer* spacecraft. His article Venus in this issue is excerpted from book *Stardust to Planets: A Geologic Ta of the Solar System* (New York: St. M tin's Press, 1993), which highlights int esting discoveries in planetary science.

Now sixty-seven years old and retired, **Arkady G. Bronnikov** (page 50) completed his Ph.D. dissertation in 1972 on problems of drug addiction in Soviet prisons. Over the years, while teaching criminology at the Institute of the U.S.S.R. Ministry of Interior in Perm, Bronnikov began collecting material on prison tattoos and criminal slang. What started as a hobby became a vocation. Although his books have not been translated into English, he has two published Russian titles: *Interpreting Tattoos Among Criminals* (1982); and with Y. P. Dubyagin, *Criminal Diagnostics and Interpretation of Tattoos Among Criminals* (1989). Until Bronnikov's Moscow exhibition of prison tattoos in February 1992, the subject was largely ignored by the popular media. writing for *Natural History,* Bronnik hopes to reach an even wider audien The article was translated by **Juliet Shapland**, who has spent many years Russia, first with Novosti Publishers Moscow, and most recently as a direct for the Council on International Exchan in Saint Petersburg.

John Moran (page 92) doesn't travel light; in this photo, he is setting off on a camping trip down the Suwannee River, his canoe loaded with everything from sleeping bags to Tiki torches. (After taking the photo, his wife, Peggy, also jumped in, along with daughters Alexis and Caitlin.) Moran has spent a lot of time on the Suwannee, working since 1984 on a photo project documenting the river's natural history and folk life. A native of Fort Myers, Moran attended the University of Florida, intending to become an architect. But when he discovered he couldn't draw, he opted for photography instead. Currently, Moran is senior photographer at the *Gainesville Sun*. In addition to his general assignment work, Moran's photographs of local wildlife are featured in the newspaper's weekly nature section. For several years, Moran had been trying to get a good picture of alligators in Paynes Prairie preserve, where he was told they gathered in great numbers. Every time he went there, however, he would see only ten or fifteen of the large reptiles. Then one evening, Moran shined his flashlight into the wetlands surrounding him and counted 2 pairs of eyes. Squeezing as many as could into a single frame, he took t "Natural Moment" photo using a Nik FE2 with a 80–200mm lens.



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NATURAL HISTORY Vol. 102, No. 12, December 1993

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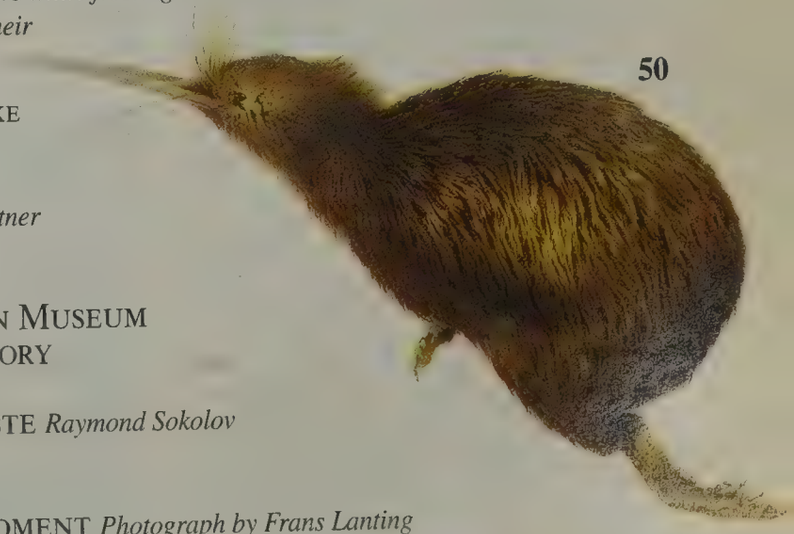
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LETTERS

THE SPIDER AND THE FLY

Readers of Ron Prokopy and Guy Bush's fascinating story, "Evolution in an Orchard" (September 1993), may be excused for mistaking the apple maggot fly in the first photograph for a jumping spider. This and the other photograph in the article illustrate beautifully how well this fruit fly resembles (in reverse) a jumping spider; the dark markings on the wings of the fly represent the anterior legs of a jumping spider, the fly's abdomen represents the spider's prosoma (head and thorax), and the fly's thorax represents the spider's abdomen. Some researchers have speculated that the spider "disguise" affords a degree of protection to this and similarly colored tephritid fruit flies, whose predators might be likely to avoid jumping spiders, which are themselves predatory creatures with a venomous bite.

PRIYANTHA WIJESINGHE
Brooklyn, New York

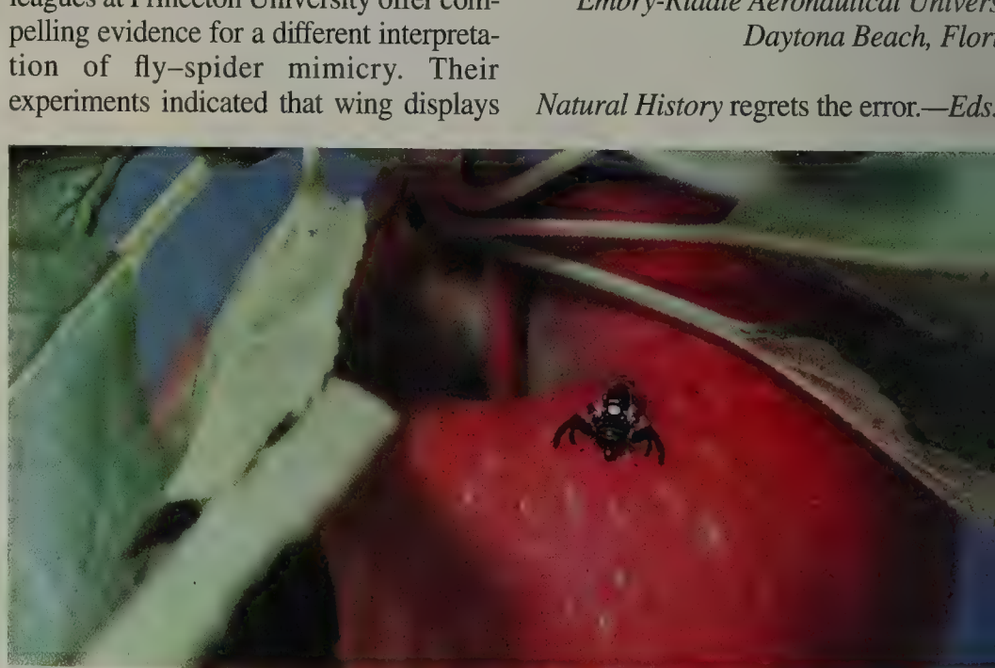
THE AUTHORS REPLY: Apple maggot flies and jumping spiders do resemble each other closely, and several biologists have indeed reckoned that by mimicking spiders, apple maggot flies and other picture-winged fruit flies might scare off predators. But in two articles in the April 17, 1987, issue of *Science,* M. H. Mather and B. D. Roitberg of Simon Fraser University in Vancouver and E. Greene and colleagues at Princeton University offer compelling evidence for a different interpretation of fly–spider mimicry. Their experiments indicated that wing displays by fruit flies caused the approach jumping spiders to display back and t retreat. When wings from houseflies w transplanted onto fruit flies, the same w displays caused spiders to attack rat than retreat. Thus, scientists conclu that the mimicry had convinced the jur ing spiders that the flies were members their own species. Interestingly, th workers found that the fruit fly's mimi of jumping spiders afforded no protect against other predators. We feel that f ther fascinating aspects of this mimicry main to be uncovered and thank those w brought it to the attention of *Natural H tory*'s readers.

ECLIPTIC CORRECTED

In "Celestial Events" for Septem 1993, the ecliptic is incorrectly defined the entry for the planet Mercury) as " earth's equator extended into space." T ecliptic is actually the plane of the eart orbit around the sun. The projection of earth's equator into space is called the lestial equator. Since the earth's rotatio axis (which, by definition, passes throu the north and south geographic poles) inclined by some 23½ degrees to the n mal of the ecliptic plane—a situation t produces our seasons—the celestial eq tor and the ecliptic are inclined by an eq amount.

ROBERT C. FLECK,
Embry-Riddle Aeronautical Univers
Daytona Beach, Flor

Natural History regrets the error.—*Eds.*



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Ron Prokopy

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Writ in Guaymi Blood

A retrovirus infecting Panamanian Indians may provide new clues about the first Americans

by Jonathan E. Kaplan

In 1981, Yorio Hinuma and other researchers in Japan were in hot pursuit of the cause of a fatal blood cancer called adult T-cell leukemia, or ATL. First recognized in 1977, the disease was most common in southwestern Japan, where about seventy cases were diagnosed each year. Its symptoms included enlargement of the lymph nodes and other internal organs, skin and bone disease, and abnormal white blood cells, or leukocytes. Treatment was generally ineffective, and the victims frequently died within one year.

The researchers discovered that the cause of the disease was a virus that had only recently been noticed by U.S. scientists. Christened human T-lymphotropic virus, or HTLV, it garnered particular attention not only because of its potential significance in cancer research but also because this was the first known example of human infection with a retrovirus—an RNA virus that changes its genetic material into DNA and inserts it into the DNA of the host organism. The HTLV virus targeted the white blood cells, within which it caused a lifelong infection.

When HTLV was discovered, scientists began perfecting laboratory techniques for detecting its presence. Antibodies against the virus could be found in the blood of those with adult T-cell leukemia, as well as in many other people. In southwestern Japan, about 15 percent of people tested had the virus. (We now know that only 2 to 4 percent of those infected develop ATL.)

In 1982, U.S. scientists discovered a similar virus, distinguishable from the original only through elaborate testing. The two viruses were then named HTLV-I and HTLV-II. We still do not know whether the second causes disease.

Interest in these viruses mounted in 1984, when a third retrovirus was found to be the cause of a much more threatening disease—AIDS (*see* "The Natural History of AIDS," *Natural History,* May 1986). Some favored calling the AIDS virus HTLV-III, but because it acts differently—by causing a failure of the immune system—it is now known as human immunodeficiency virus, or HIV. While HIV has grabbed the headlines, the HTLV viruses have continued to provide surprises of their own.

Scientists noted that ATL clustered in families; we now know that HTLV-I, like HIV, can be both sexually transmitted and spread from mother to child (primarily through breast-feeding). Indeed, infection at or near the time of birth seems to be required for this very slow-acting virus to cause ATL, although not all who are infected at that stage get the disease. The virus is also transmitted through blood transfusions and the use of contaminated hypodermic needles.

Scientists also learned that in less than one percent of those infected, HTLV-I caused a neurologic disease similar to multiple sclerosis. Originally observed in the Caribbean, this illness was given the name tropical spastic paraparesis. Soon afterward, however, it was recognized in Japan; and since Japan is not a tropical country, it was renamed HTLV-I-associated myelopathy, or HAM. This disease is now referred to as HAM/TSP. A genetic cofactor may be important for its development; and unlike ATL, it can be caused by infection later in life.

Among those intrigued by HTLV-I were physician William Reeves and others at Panama's Gorgas Memorial Laboratory (named for William Gorgas, a physicia who was a pioneer in the conquest of ye low fever in Panama). Both ATL ar HAM/TSP were found to be common some Caribbean islands, and blood tes for HTLV-I were positive in many health individuals. By then the virus and its ass ciated diseases, as well as a closely relate monkey virus, had also been found Africa. Thus, researchers assumed th virus had come to the Caribbean by way the slave trade. Since Panama borders th Caribbean, Reeves wondered whethe people in Panama were also infected wi this virus. In the mid-1980s, he decided find out.

In earlier years, Reeves and his co leagues had conducted numerous studie of infectious diseases in various Panaman ian populations. The hundreds of bloo specimens they had collected were store in freezers in Panama City. Since invest gators at the National Institutes of Healt (NIH) had developed tests for measurin antibodies against HTLV-I, Reeves raide the freezers and sent the blood specimen to Maryland.

The result of this effort was a map o Panama showing the prevalence of ant bodies against HTLV-I in different re gions. Most of the figures were below on percent, but two samplings of Guaymi In dians in northwestern Panama (about 15 individuals in each case) suggested an in fection rate of about 9 percent. Other tha certain groups of intravenous drug users i the United States (in whom HTLV-I infec tions appeared to be common), this wa the highest rate reported in any populatio in the Western Hemisphere.

Working with Reeves, I and others a the Gorgas Memorial Laboratory and a


The
story's changed
somewhat
over the years as
older
generations of the
family tell
it to newer ones.
But somehow
no one ever gets too
tired to tell it,
or too bored to listen.
In the end,
it isn't so much that
we're in
the story; but that
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NIH pursued this finding in a larger sampling of the Guaymi. Numbering about 70,000, the Guaymi inhabit several provinces of northwestern Panama and neighboring Costa Rica. They are descendants of Indians who retreated to the mountains during Spanish colonization and who have remained relatively isolated in this rugged, nearly inaccessible jungle area ever since. We decided to test Guaymi in Changuinola, a town to which many migrate to live and work on the banana plantations. Changuinola was a convenient research site, having a hospital with a laboratory where blood specimens could be processed before shipment to Panama City, a one-hour flight away. Tests were performed there and then confirmed at the U. S. Centers for Disease Control (CDC) in Atlanta, Georgia.

In 1988 we tested more than 300 Guaymi, with results nearly identical to those in the two previous samples—an infection rate of 8 percent. We were excited about confirming the unusually high rate. But more importantly, perhaps, we saw indications that the Guaymi virus was not the same as the one infecting Caribbean populations.

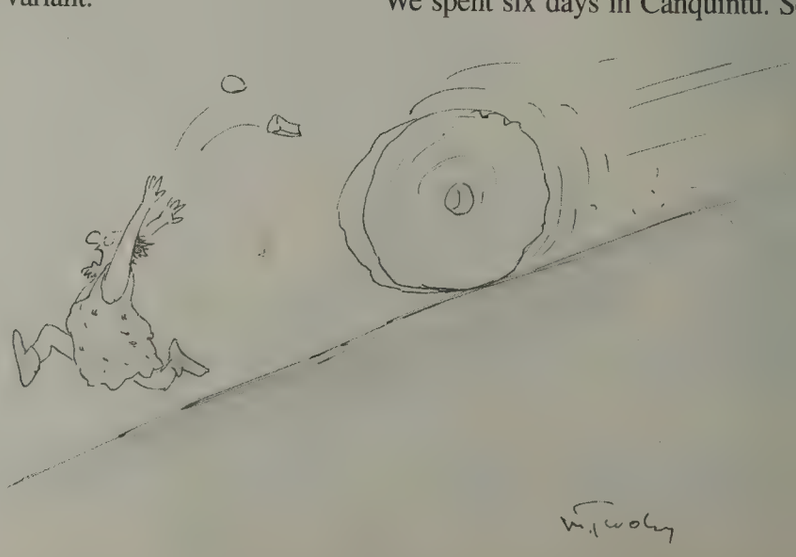
First, in populations in the Caribbean, the rate of infection was higher in females than in males (suggesting that the virus is more easily transmitted sexually from men to women than vice versa). In the Changuinola Guaymi, however, male and female rates were similar. Second, in most populations in which HTLV-I had been found, infections clustered within households, but we could not initially discern such clustering in the Guaymi (household clustering only became apparent to us much later, when we analyzed larger numbers of Guaymi). Third, we could not find any cases of ATL or HAM/TSP. Finally, the reaction of antibodies in lab tests differed from the usual pattern, indicating the possibility of a variant.

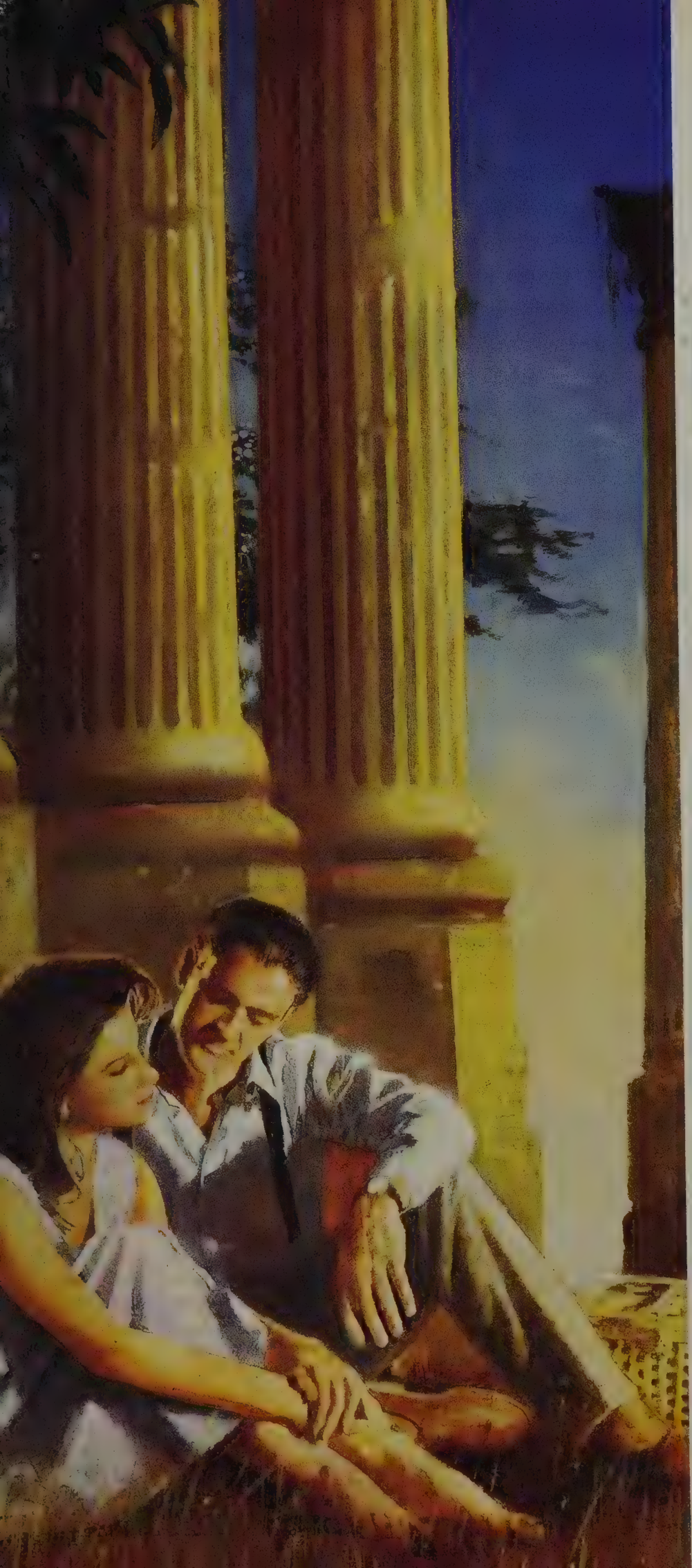
We wondered whether the high rate infection among the Guaymi Changuinola was typical of all Guay including those living in more rural are The Guaymi in Changuinola lived in co tact with people of mixed Indian and H panic descent (mestizo), as well African-American populations, and mig have acquired the virus as a result. Ideal we would have liked to have test Guaymi living scattered throughout t jungle, but the logistical obstacles to su an effort were formidable. We therefo selected one village—Canquintu, popul tion 400. The village had a church, women's vocational school, a prima school, and handiest for us, a medic clinic.

The journey to Canquintu fro Changuinola entailed a one-hour bus rid a five-hour boat ride across a protecte inlet of the Caribbean called Lagu Chiriqui, and a twenty-mile boat ride u the Rio Cricamola. The last leg of the tri in two open boats, was not a simple fea We were seven doctors, six nurses, o laboratory technician, and two boatme Along with a great deal of equipment f collecting, processing, and storing bloo specimens, we brought a forty-four-gallo drum of diesel fuel to power our cen trifuge. (The village had a diesel-powere generator, but we did not want to deple their supply of fuel.) And of course, w had our personal gear for a week's stay i Canquintu.

Our boats labored under their loads a the current became more swift, and we re alized that we would not reach Canquint by nightfall, if at all. As darkness ap proached, we beached the boats at a vi lage and arranged to spend the night. Th following day, the boatmen navigated th boats without passengers the remainin five miles to Canquintu while we walke through the jungle.

We spent six days in Canquintu. Som





In a roaring fireball, an era of grace ended.



Architect Robert Parker Adams considers the ruins of Windsor.

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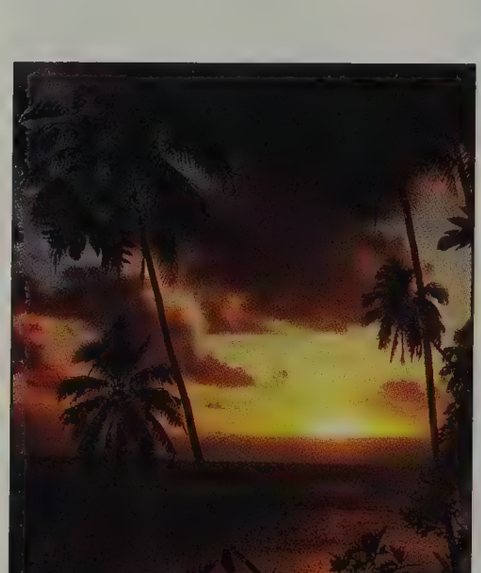
The South's Warmest Welcome

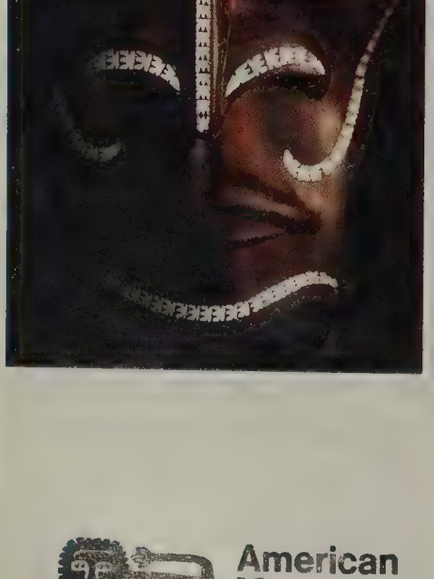
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MYTHS AND REALITIES OF POLYNESIA

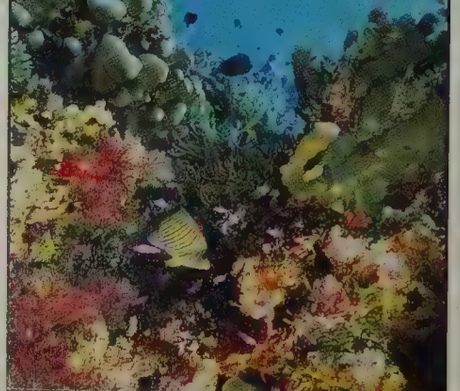
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of the doctors worked in the medi clinic, administering medicines to Guaymi, while others worked with nurses, interviewing village residents a collecting more than 300 blood spe mens. Subsequent work in the laborato confirmed that the Canquintu Guay were infected, although the rate—abou percent—was lower than in Changuin (we still don't know why). On this sa trip, we were able to collect white blo cells from three people who had test positive in the Changuinola study. hoped to use new laboratory techniques analyze the viral DNA within these ce and to characterize it. We also hoped grow the virus for further study.

A few months later, thanks to so very sophisticated work by Michael La more at the CDC and Steven Jacobson NIH, we discovered that the virus in t three Changuinola Guaymi was HTLV- and not HTLV-I. We had not anticipat this development, but it offered a possib explanation for the anomalies we had o served. Subsequent work confirmed th all the persons who had tested positive both Changuinola and Canquintu were fact infected with HTLV-II.

We were now faced with the question the origin of the HTLV-II virus in t Guaymi. One likely explanation was tha like many other infections found in Ame ican Indians, the virus had come from t outside at some point after the Europe conquest. However, the Guaymi have tr ditionally lived isolated from neighborin populations. Even in Changuinola, whe mestizo and black populations live, t Guaymi keep to themselves, and interma riage is taboo.

We considered the possibility of illic contacts. Some Guaymi men occasional frequent prostitutes in Changuinola and neighboring Costa Rica. Fernando Graci a neurologist in Panama who has collab rated in the HTLV studies, obtained bloo samples from some of these women f testing. These proved to be negative, cas ing doubt on that theory.

HTLV infections can also be transmi ted by contaminated needles, and we co sidered that possibility as well. Recent in formation suggests, for example, that mo of the drug users in the United States wh test positive for HTLV are infected wit HTLV-II. However, illicit use of drugs unknown among the Guaymi, and dispos able needles are used in the health car system.

An alternative hypothesis was tha HTLV-II had been present among th

ymi and their ancestors for a long , perhaps even before the European quest. The virus causes lifelong infec- and thus could have persisted in rela- y small, isolated populations. In con- t, "crowd-type" viruses, such as llpox and measles, cause brief infec- s in individuals and therefore require a e human population pool for their g-term survival.

About this time, evidence of HTLV-II ction among several other American ian groups began to appear. Brian lle, a physician working with a large od banking organization in the Ameri- Southwest, reported that several dona- is had tested positive for HTLV-II. st had come from local Indian ups—Athapaskan and Pueblo. The two ups, which are linguistically and cul- lly distinct, are believed to have ar- ed in New Mexico at different times and ave had very little intimate interaction h one another. Similarly, Paul Levine m NIH reported some HTLV-II infec- ns among Florida Indians. And a group ded by William Blattner at the NIH has nd the virus in relatively isolated ups of South American Indians. All of se observations suggest that HTLV-II s present in the New World before lumbus.

Like HTLV-I, HTLV-II may have origi- ed in the Old World. In 1992, for ex- ple, a Belgian group detected some TLV-II infections among Pygmies in ire. But if the virus first arose in the Old rld, how did it reach scattered Indian pulations in the Americas? Most schol- s agree that the ancestors of the Ameri- n Indians arrived over the Bering land dge in waves of migration during the t ice age, from 35,000 to 10,000 years o. One or more of these groups may ve brought HTLV-II with them.

If the virus arrived with the first Ameri- ns, it should exist among aboriginal oups in northern Asia. Only limited udies have been done among Siberian pulations, however, and these have iled to find the virus. The search goes on. leanwhile, in collaboration with Michael avidson and others from the Arctic In- estigation Laboratory in Anchorage, my lleagues and I have looked for the virus n the New World side of the Bering land ridge, among native Alaskans.

We tested blood samples from more an 300 individuals and found no evi- ence of HTLV-II and a very low preva- nce of HTLV-I—about 0.5 percent. Var- us other studies have concluded that the ancestors of native Alaskans were among the last to migrate from Asia to the Americas. Our results, although based on a relatively small survey, suggest that they did not carry HTLV-II. If the virus came from Asia, it arrived with some earlier wave of migrants.

Recent molecular investigations have added a new twist to our research by identifying two subtypes of the HTLV-II virus—"a" and "b." Preliminary work led by Robert Biggar at NIH, analyzing a limited number of Indian populations, appears to show that the first subtype is distributed in South America, while the second is found in North America. The HTLV-II found among African Pygmies has yet to be specified, leaving us in doubt as to whether one or both or neither of these two variants exists in the Old World. But in time, these and other variants may enable us to trace the ancient connections between peoples of the Old and New Worlds.

Jonathan E. Kaplan, M.D., is an infectious disease epidemiologist at the Centers for Disease Control and Prevention in Atlanta, Georgia. The opinions expressed here are his own.



Four Metaphors in Three Generations

To commemorate his twenty years in Natural History, *a columnist examines the writing techniques of two Darwins*

by Stephen Jay Gould

Michel de Montaigne, traditional founder of the essay as a literary genre, wrote a short letter as a preface for his *Essays* (1580). He stated "to the Reader":

I desire therein to be viewed as I appear in mine own genuine simple, and ordinary manner.... If I had lived among those nations, which (they say) yet dwell under the sweet liberty of nature's primitive laws, I assure thee I would most willingly have painted myself quite fully and quite naked.

I began this series of essays in January 1974, and this column represents the completion of twenty continuous years. I should therefore use this occasion to celebrate what our founder Montaigne defined as crucial to the genre—ordinary things (with deeper messages). Besides, I have always seen myself as a meat-and-potatoes man. You can take your ravioli stuffed with quail and...well, stuff it somewhere. (I am also quite capable of releasing my own ground pepper from a shaker.)

My first trip to Greece, in the fall of 1991, became my most exhilarating celebration of the ordinary—for I discovered that many of our most abstract and highfalutin words, often invented by pedants to showcase their knowledge of ancient languages and intended to debar the general public from such rarefied information refer to plain and ordinary things in th land of their etymological birth. For blessed moment of joyful hubris, I though that all of Greece was celebrating our the ory of punctuated equilibrium, with its ke claim for what Niles Eldredge and I calle stasis, or lack of substantial change durin the geological history of most specie (yeah, we might have called the phenome non stability, but stasis had that nice slightly jargony ring and stood clos enough to the vernacular for comprehen sion). But then I saw all these large, rec tangular vehicles pulling up to "stasis signs and realized that local government were only marking their bus stops!

I also learned a lot about derivation and change in meaning. I wondered wh the *domestic* airlines terminal bore th name Esoteriki—for esoteric things ar strange and obscure and should therefor mark, or so I supposed, the entrance poin for foreigners at the international terminal But I learned later, from my *Oxford English Dictionary,* that esoteric came to mean "obscure" because the word designates information vouchsafed only to initiated members of an inner circle, and therefore mumbo jumbo to others. *Eso* means "within" in Greek, and therefore becomes appropriate for domestic flights (they ought to know, after all). I also couldn't figure out why the area of a church set aside for candles and votive offerings bore the apparently contradictory sign Anathemata. But *anathema,* in Greek, is an offering (literally, a thing set up). Greek churches still use the original sense of "an object devoted or consecrated to divine use"; only later did the word acquire a restricted, and usually opposite, meaning of

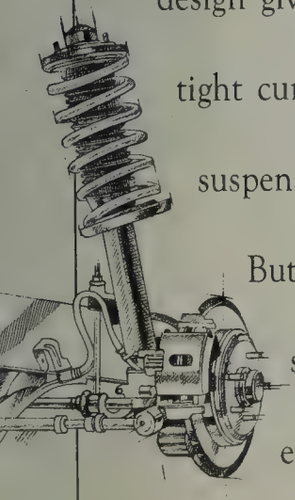


Harvard professor Stephen Jay Gould learns the meaning of stasis *in Greece.*



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"a thing dedicated to evil" (in ecclesiastical Latin, an *anathema* is an excommunicated person).

One day, as I sat at an alfresco lunch spot enjoying a view of the Acropolis, a small truck pulled up to the curb and blocked the Parthenon. I was annoyed at first, but later wonderfully amused as I watched the moving men deliver some furniture to the neighboring house. Their van said Metaphora. Of course, I realized. *Phor* is the verb for "carrying," and *meta* is a prefix meaning "change of place, order, condition, or nature." A moving truck helps you change the order of something by carrying it from one spot to another—and is surely a metaphor. I then discovered that all sorts of carriers are metaphors, including the wheels for your airplane luggage.

How lovely. In school, I was frustrated almost to tears in struggling to grasp the differences among various kinds of images: metaphors, similes, eponyms, metonyms, synecdoches—and all this after mastering the distinction between iambs and dactyls. (I learned these words, by the way, at P.S. 26 in Queens, not in some fancy private school. The New York City public schools actually taught this stuff not long ago.) If only I had known about that little, concrete moving van! A metaphor carries you from one object (which may be difficult to understand) to another (which may be more accessible and therefore helpful, by analogy, in grasping the original concern).

I love metaphors; I use them all the time in these essays and have even written a column or two specifically on the subject of metaphors and their uses. The human mind is a wondrously obtuse and circuitous instrument. We think of ourselves as logical, as able to move in deductive order through a set of arguments from beginning to ineluctable conclusion. But we almost never work in such an idealized way. We always encounter obstacles and chasms that require a creative leap—a mode of imaginative bridging that our greatest philosopher, C. S. Peirce, called abduction, or leading from, to contrast with the recognized and tamer methods of deduction, or logical sequencing, and induction, or generalizing from empirical cases. And we need carriers, or metaphors, to make such imaginative leaps. Moreover, a scholar's choice of metaphor usually provides our best insight into the preferred modes of thought and surrounding social circumstances that so influence all human reasoning, even the scientific modes often viewed as fully objective in our mythology.



Metaphors, as Gould learned in Greece, can carry luggage as well as ideas.

But metaphors also present twin dangers, literary and intellectual. On the structural side, some metaphors are so silly or obtuse that we end up laughing (or scratching our heads) rather than gaining enlightenment. Among famous examples, I would submit the opening verse of Psalm 42: "As the hart panteth after the water brooks, so panteth my soul after thee, O God." (I had particular reservations about this image because I first learned the psalm through oral recitation, pictured "heart" instead of "deer," and then couldn't imagine what one of my inner organs would do with a river. I also had trouble with souls panting—dogs, yes; ethereal versions of me, never.) On the conceptual side, many images are flat wrong—from the ladder of life to the king of beers to the evil empire.

The distinction of metaphors, between useful and ineffective, brilliantly insightful and dismally misleading, therefore becomes an important consideration in making or evaluating any complex intellectual argument. But how shall we set up a catalog of criteria? I will not address this vital subject in the abstract, but will devote this essay instead to providing matched examples, from which we might extract some general guides. I will discuss two celebrated and related authors, separated by generations—a grandfather and his mo famous grandson. I will present fo metaphors central to the primary argume of each writer. I will claim that grandfath Erasmus Darwin gained little but verbia from his efforts, whereas grandso Charles deftly used metaphors not only illuminate but also to advance his epoch theory of evolution by natural selection.

Erasmus Darwin (1731–1802)—prom nent liberal thinker of Britain's Enlighte ment, successful physician and scientis respected poet in his era's favorite style heroic couplets (written in iambic pe tameter, not in dactyls; you see, Mr Ponti, I do remember the difference)– published his most remarkable work 1789, *The Loves of the Plants*, highlighte in last month's essay. In 4 cantos and 23 pages of verse, he described and illu trated Linnaeus's sexual system for class fying plants by personifying stamens male humans, pistils as female human and then drawing out the consequences heroic couplets. As if this device were n metaphor enough, Erasmus Darwin the added another layer by comparing the pe sonified flower to classical myths or cu rent events. I will illustrate his techniqu by discussing four of these secondar metaphors, admittedly selected for the more forceful imagery (but by no mean atypical of Darwin's poetic strategy).

1. *Sequential fertilization in* Glorios *and the suicide of Ninon's son. Glorios* belongs to Linnaeus's class Hexandria, six stamens for a single pistil in eac flower. In Darwin's first metaphor, he mus therefore describe six lovers with on woman. Since fertilization is sequential i *Gloriosa*—one group of three stamen first, followed by the second group o three—Darwin invokes the risqué imag of an older seductress, a Mrs. Robinson using wiles to captivate the second grou of three after her physical beauties hav faded:

> When the young Hours amid her tangled hair
> Wove the fresh rose-bud, and the lily fair,
> Proud *Gloriosa* led three chosen swains,
> The blushing captives of her virgin chains.—
> When Time's rude hand a bark of wrinkles spread
> Round her weak limbs, and silver'd o'er her head,
> Three other youths her riper years engage,

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The flatter'd victims of her wily age.

Darwin then cements this metaphor with another image from recent history. Ninon de Lenclos (1620–1705), lover of more famous Frenchmen than this essay has space to list, ended life as a respectable socialite (Voltaire's father managed her business dealings, and she left money for the young Voltaire in her will), but accumulated quite a string of legends from her earlier years, including this tale of sexually enticing her own son (with dire consequences), recounted by Erasmus Darwin as a metaphorical comparison with *Gloriosa*—quite inappropriate since *Gloriosa*'s stamens lie within one flower and represent a single generation, whatever the spacing of fertilization:

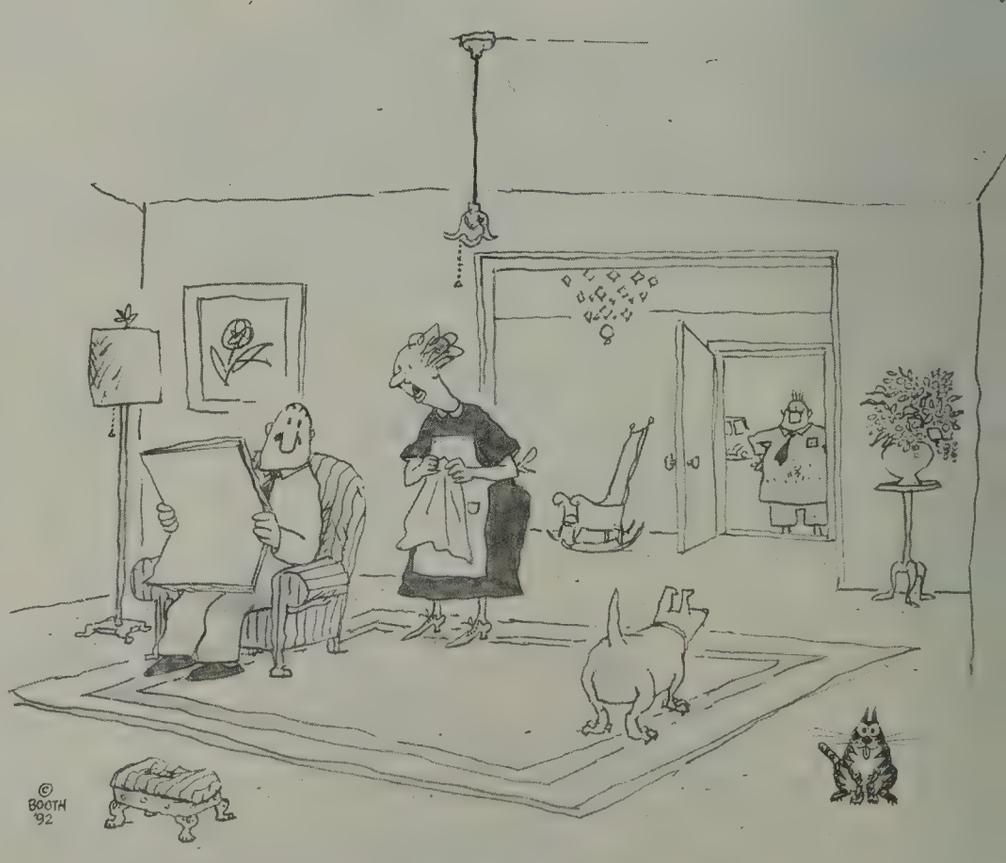
So, in her wane of beauty, Ninon won
With fatal smiles her gay unconscious son.—
Clasp'd in his arms she own'd a mother's name,—
"Desist, rash youth! restrain your impious flame,
"First on that bed your infant form was press'd,
"Born by my throes, and nurtured at my breast."
Back as from death he sprung, with wild amaze
Fierce on the fair he fix'd his ardent gaze;
Dropp'd on one knee, his frantic arms outspread,
And stole a guilty glance toward the bed;
Then breath'd from quivering lips a whisper'd vow,
And bent on heaven his pale repentant brow;
"Thus, thus!" he cried, and plung'd the furious dart,
And life and love gush'd mingled from his heart.

2. *Spreading seed in* Impatiens *and the slaying of Medea's children.* Darwin writes exactly four lines on *Impatiens,* the touch-me-not, describing how this plant, if touched when the seeds are ripe, "suddenly folds itself into a spiral form…and disperses the seeds to a great distance." Darwin follows with three pages on Euripides' tale of Medea, who killed her own children by Jason (of Golden Fleece fame), when Jason betrayed her for the daughter of King Creon. The comparison with *Impatiens* seems awfully forced, for the seeds of *Impatiens* are fertile, and what does growing a plant hold in common with killing children—except that Medea threw her slain offspring to the ground, just as *Impatiens* tosses seeds violently to earth. Moreover, with four lines on *Impatiens* and three pages on Medea, one must suspect that Darwin is using botany as an excuse for retelling the gory details of Euripides' tragic figure, rather than invoking the human story to illuminate the plant, as advertised:

Thrice with parch'd lips her guiltless babes she press'd
And thrice she clasp'd them to her tortur'd breast;
Awhile with white uplifted eyes she stood,
Then plung'd her trembling poniards in their blood.
"Go, kiss your fire! go, share the bridal mirth!"
She cry'd, and hurl'd their quivering limbs on earth.

3. *Plants that disperse their seeds by the wind and Montgolfier's balloon.* At the beginning of the second canto, Darwin describes several plants with windblown seeds. Just as we knew the excitement of humanity's first flights into space and our grandparents felt the thrill of aviation's earliest days, Erasmus Darwin's generation experienced the elation of our first elevation above the earth's surface—the discovery of ballooning. The brothers Montgolfier in France, the great pione of this art, became culture heroes beyo the Wright brothers, beyond Lindber beyond Neil Armstrong's giant leap mankind. Darwin really wanted to wr about his great contemporaries, and c feels again that the plants serve as an e cuse to describe the human achieveme not vice versa as his metaphorical meth supposedly advocates. Darwin waxes p ticularly lyrical in describing the flight Montgolfier's balloon above the cosmos so much so that we will need some exp nation (to be given after the citation) sort out the flowery images:

So on the shoreless air the intrepid Gaul
Launch'd the vast concave of his buoyant ball.—
Journeying on high, the silken castle glides
Bright as a meteor through the azure tides;…
Rise great Montgolfier! urge thy venturous flight
High o'er the Moon's pale ice-reflecte light;
High o'er the pearly Star, whose beamy horn
Hangs in the east, gay harbinger of morn;
Leave the fair beams, which, issuing from afar,



"It's Mr. Trudoe from next door. He wants to know are you ready to settle this thing about Darwin's Theory?"

ay with new lusters round the
Georgian star;...
or thee Cassiope her chair withdraws,
or thee the Bear retracts his shaggy
paws.

o make sense of all this, you must re-
that Montgolfier's balloon is receding
ner and farther from earth. It first
es Venus, the morning star ("gay har-
er of morn") which, like the moon,
phases ("beamy horn"). It then moves
ugh the planets in order—Mars,
ter, and Saturn—and out to the stars,
re the constellations of Cassiopeia (a
sitting in a chair) and Ursa Major (the
t bear, including the Big Dipper in its
move aside in homage to let the bal-
n pass. But now we must track back to
hard one (two bits to any reader who
w the answer before reading this para-
ph). What is the "Georgian star"? An-
r: The planet Uranus, next in line after
urn. When the great astronomer
liam Herschel discovered Uranus (the
t planet found by telescope) in 1781,
eight years before Darwin's book, he
ned it Georgium Sidus (or Georgian
net) to honor his patron, King George
Thankfully for Americans, who have
er been particularly keen on mad King
orge, especially since Jefferson penned
h a powerful list of the king's wrongdo-
s in the Declaration of Independence,
exercise in chauvinistic designation
n't stick. All the other planets bore clas-
al names that honored no modern na-
n or monarch, so astronomers eventu-
accepted the suggestion of J. E. Bode,
de in the same year as Herschel's dis-
ery, that the new planet be named for
anus, the father of Saturn (just as Saturn
s the father of Jupiter, thus preserving a
per correlation of distance with genera-
n).

4. *Migrating plants to the birth of*
ses and to the abolition of slavery. The
l of canto three features Darwin's most
ended and far-fetched metaphor. He
aks first of American plants whose
ds can cross the Atlantic and still ger-
nate in Europe:

Where vast Ontario rolls his brineless
tides,
And feeds the trackless forests on his
sides,
Fair *Cassia* trembling hears the
howling woods,
And trusts her tawny children to the
floods....
Soft breathes the gale, the current
gently moves,

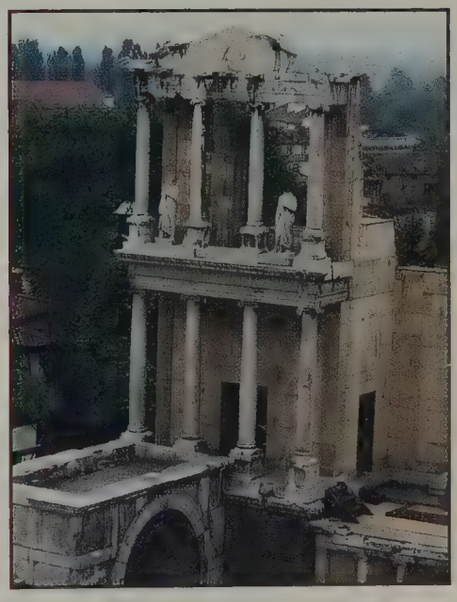
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And bears to Norway's coasts her
infant loves.

The comparison to Moses seems obvious enough, for the great prophet was placed into the Nile in a basket and floated to safety:

With paper-flags a floating cradle
weaves,
and hides the smiling boy in Lotus-
leaves;
Gives her white bosom to his eager
lips,
The salt-tears mingling with the milk
he sips;
Waits on the reed-crown'd brink with
pious guile,
and trusts the scaly monsters of the
Nile.

The transition to slavery is a bit forced. Moses lifted the yoke of his nation ("let my people go" and all that), while slaves, just like seeds, are transported across oceans.

E'en now, e'en now, on yonder
Western shores
Weeps pale Despair, and writhing
Anguish roars:
E'en now in Afric's groves with
hideous yell
Fierce Slavery stalks, and slips the
dogs of hell.

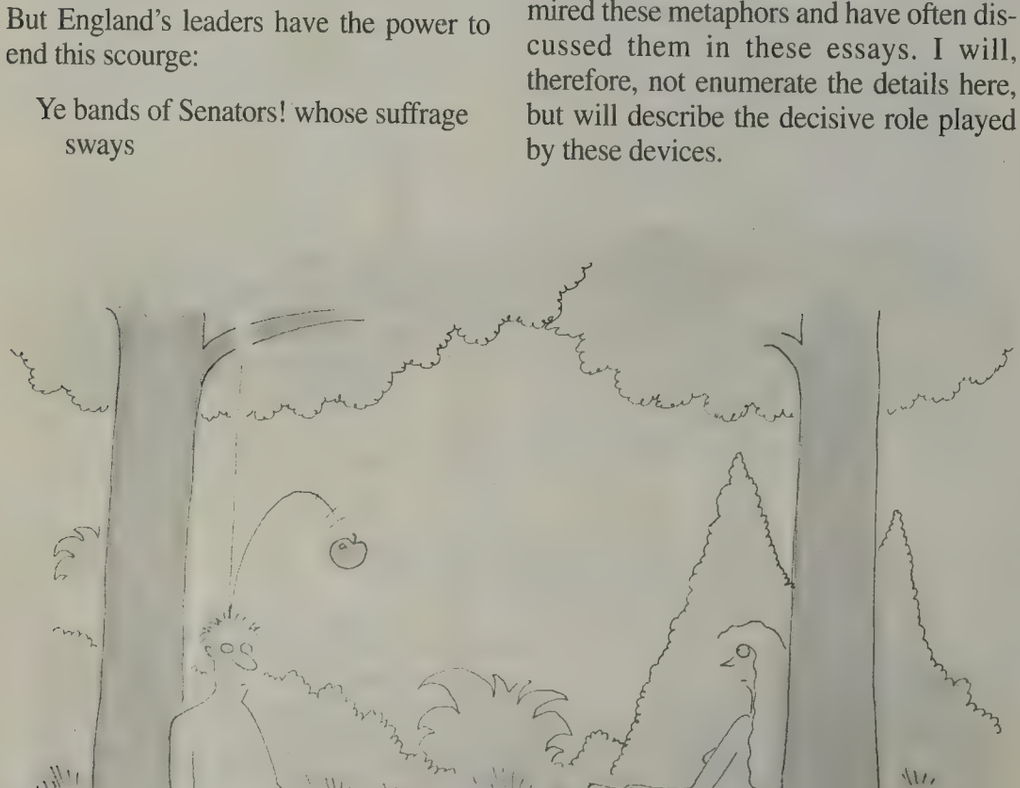
But England's leaders have the power to end this scourge:

Ye bands of Senators! whose suffrage
sways
Britannia's realms, whom either Ind
obeys;
Who right the injured, and reward the
brave,
Stretch your strong arm, for ye have
power to save!...
Hear him, ye Senates! hear this truth
sublime,
"He, who allows oppression shares the
crime!"

Admirable sentiments, forcefully (if a bit floridly) expressed—but quite a stretch from floating seeds.

Charles Darwin, so unlike his grandfather, made no attempt at lyrical writing. He composed the *Origin of Species* (1859) as a general work for a literate public, not as a technical treatise for scientists. Still, Darwin's prose, while clear, tends to be dry and measured. Much of the *Origin* is a list of supporting facts for evolution.

Nonetheless, Charles Darwin understood that difficult and controversial concepts could not be sold by factual accumulation alone. He knew that he had to make a convincing case (in a famous passage, Darwin calls his book "one long argument"). Darwin also sensed that imagery and metaphor must be used as indispensable tools in the art of persuasion. At several crucial moments in the book, Darwin therefore introduces key metaphors to illuminate essential points. I have long admired these metaphors and have often discussed them in these essays. I will, therefore, not enumerate the details here, but will describe the decisive role played by these devices.



Charles's strategy is so different fr
his grandfather's. Erasmus tried to dro
us in a gushing flood of florid langua
creating a soup so thick that an occasio
tidbit of wonderful taste gets lost in
goo. Charles knew the value of numero
metaphors about needles in haystacks
roses amid the thorns. He grasped
virtue of rarity and therefore strikes us
tween the eyes every few dozen pag
with a metaphor so appropriate, and so
pansive, that natural selection becomes
familiar friend rather than an arcane a
distant concept. Consider my four
vorites, including the keystone of the
tire book.

1. *Superficial appearances and deep realities of nature.* Darwin faced the su
stantial problem of reorienting his public
fundamental concept of nature's ord
Most people viewed nature as basical
benevolent, created in perfection, a
largely for human benefit, by a lovi
God. Darwin's theory required a stunni
reversal to a world devoid of intrinsic pu
pose, developing limited order only as
side consequence of nature's true causa
ity: the struggle among organisms for pe
sonal reproductive success. To facilita
this flip in perspective, Darwin develope
a brilliant metaphor to contrast extern
appearances with internal reality:

We behold the face of nature bright wi
gladness, we often see superabundance
food; we do not see, or we forget, that th
birds which are idly singing round u
mostly live on insects or seeds, and are th
constantly destroying life; or we forget ho
largely these songsters, or their eggs,
their nestlings, are destroyed by birds a
beasts of prey.

2. *The driving force of competition in a crowded world.* For natural selection t
work relentlessly, the world must be full
competitors; otherwise, the ill-adapte
might live forever by moving to some pre
viously unoccupied real estate. At a cru
cial point in his argument, Darwin firs
states the idea of perennial competition di
rectly and then reinforces his key poi
with a metaphor about natural crowding
new forms can only enter a full terrain b
driving others out (new wedges insinuat
themselves at their thin edges—to cite an
other common image—and eventuall
force others out).

In looking at Nature, it is most neces
sary...never to forget that every single or
ganic being around us may be said to b
striving to the utmost to increase in num
bers; that each lives by a struggle at som
period of its life; that heavy destruction in

ably falls either on the young or old, ng each generation.... The face of Na- may be compared to a yielding surface, n ten thousand sharp wedges packed e together and driven inwards by inces- t blows, sometimes one wedge being ck, and then another with greater force.

The tree of life. Darwin presents the ory of natural selection in the first four pters of the *Origin* (he devotes the rest he book to refuting objections and mar- ling evidence for evolution). Interest- ly, as an epitome of his entire argu- nt, Darwin chooses to end chapter 4 th an elaborate metaphor based on omparison of life's history to the growth a tree. Darwin, of course, did not invent e tree of life, an old biblical image roverbs 3:18, for example) that had also en employed to express taxonomic rela- nships among organisms. But Darwin ded a dynamic element in comparing ing and dead branches with successful d failed lineages subject to natural se- tion (with extinct groups of the fossil cord depicted as broken limbs at the e's base)—a brilliant and complex age combining taxonomic structure th causal production.

e affinities of all the beings of the same ss have sometimes been represented as a eat tree. I believe this simile largely eaks the truth. The green and budding igs may represent existing species; and se produced during each former year ay represent the long succession of extinct ecies. At each period of growth all the owing twigs have tried to branch out on sides, and to overtop and kill the sur- unding twigs and branches, in the same anner as species and groups of species ve tried to overmaster other species in the eat battle for life. The limbs divided into eat branches, and these into lesser and sser branches, were themselves once, hen the tree was small, budding twigs; and s connection of the former and present ds by ramifying branches may well repre- nt the classification of all extinct and liv- g species in groups subordinate to groups.

Darwin then ends the chapter with a re flourish of truly lyrical prose:

s buds give rise by growth to fresh buds, d these, if vigorous, branch out and over- p on all sides many a feebler branch, so by neration I believe it has been with the eat Tree of Life, which fills with its dead d broken branches the crust of the earth, d covers the surface with its ever branch- g and beautiful ramifications.

4. *A central argument based on anal- y, not direct evidence.* The preceding ree metaphors are helpful images, de- gned to clarify unfamiliar (even socially



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objectionable) concepts crucial to the acceptance of natural selection. But Darwin uses metaphor in a much deeper way by rooting his entire argument in a fundamental analogy. Darwin begins his book by discussing domestic pigeons and then presents voluminous information—well known, fully documented, and not subject to doubt—about substantial historical change achieved by human intervention in domesticating animals and improving food crops. But Darwin knew that he could not prevail by recounting this incontrovertible information: he had to convince readers that much greater changes through much longer times could also occur by transmutation. But geological time is not available for direct experimentation: one might document the results of large-scale evolution, but how can you demonstrate causality by natural selection? Darwin therefore proceeded by a grand analogy: If we know that humans can make small changes in limited time by a process that Darwin called artificial selection, then, surely, the much more powerful forces of nature can accomplish any amount of evolution in the ample time allowed—by a process that Darwin named, by analogy, natural selection. Our little, but palpable, world of domestication and agriculture therefore becomes a metaphorical microcosm for nature's unobservable grandness:

> As man can produce and certainly has produced a great result by his methodical and unconscious means of selection, what may not nature effect? Man can act only on external and visible characters: nature cares nothing for appearances.... She can act on every internal organ, on every shade of constitutional difference, on the whole machinery of life.... How fleeting are the wishes and efforts of man! how short his time! and consequently how poor will his products be, compared with those accumulated by nature during whole geological periods.

If we ask why Erasmus's metaphors seem so unhelpful, even obtrusive, and why Charles's are so apt and useful, two major differences stand out: First, Erasmus's comparisons seem either forced (expulsion of *Impatiens* seeds to Medea's murdered children, seeds floating to Norway to Moses floating down the Nile) or pedestrian (aerial seeds to Montgoflier's balloon); the linkage therefore doesn't help us to understand the biological example—whereas Charles's imagery illuminates his science (the tree of life as both dynamic and genealogical, artificial selection as an extended analogy to nature's much greater potential).

Second, Erasmus's balances seem out of whack if the metaphors are meant to clarify the science—for they often extend for pages after a few telegraphic lines about plants, and one suspects that botany has become an excuse for florid versification about classical tragedies and modern triumphs (although we thought that the verses were meant to illuminate the flowers). Charles's metaphors, on the other hand, are short and pungent, often only a phrase in length ("the face of nature bright with gladness"), and always subservient to a scientific point thus clarified.

Perhaps I am being unfair to Erasmus in this comparison. After all, his chosen genre is so different from his grandson's. He composed a long poem on purpose, so of course his imagery must be more extensive, whereas Charles wrote a more conventional prose work of science. But Erasmus also presents an explicit theory of metaphor that virtually guarantees the limited scientific utility of his images—and on this basis we may justly make the comparison. Erasmus develops these views in sections of *The Loves of the Plants* that have won practically no attention from scholars and commentators (who love to quote the heroic couplets)—the three prose interludes, placed between the four cantos of the books, and written in t form of dialogues between a poet (Darw himself) and a bookseller (who, he hope will flog the volume successfully).

Erasmus Darwin introduces his book l defending the search for apt comparison arguing that the complexity of natural o jects produces a plethora of relationshi among them, all worthy of exploratio "Since natural objects are allied to eac other by many affinities, every kind of th oretic distribution of them adds to ou knowledge by developing some of th analogies." But, in the first interlude, th poet then drives a wedge between poetr and science by banishing the loose im agery of metaphor from science, wher logic must hold sway, while defendin such verbal pictures for poetry, whose pu pose Darwin conceives as primarily v sual—"bringing objects before the eye, c expressing sentiments in the language c vision:" "Science," Erasmus writes, "i best delivered in Prose, as its mode of rea soning is from stricter analogies tha metaphors or similes."

Erasmus then tells us that his poetic im ages are not even intended to clarify hi botany, but for two other purposes. Firs Erasmus argues, both poets and painter succeed by idealizing nature, not by accu



depiction: "The farther the artist re-
:s from nature, the greater novelty he is
ly to produce; if he rises above nature,
oroduces the sublime; and beauty is
oably a selection and new combination
ier most agreeable parts" (see my col-
a of June 1993 for Burke's distinction
he sublime and the beautiful, followed
e by Darwin's). Second, metaphors and
iles, as poetic visions, should be di-
ssions from nature, not illuminations of
actuality. Using a lovely archaic
rd—to "quadrate," or literally to
uare with"—Erasmus defends the first
at poet:

t the similes of Homer have another
reeable characteristic; they do not
adrate, or go upon all fours (as it is
led).... Any one resembling feature
ms to be with him a sufficient excuse for
introduction of this kind of digression;
then proceeds to deliver some agreeable
etry on this new subject, and thus con-
rts every simile into a kind of short
sode.

Finally, the poet lays it on the line, when
bookseller queries: "Then a simile
ould not very accurately resemble the
oject?"

; it would then become a philosophical
alogy, it would be ratiocination instead of
etry; it need only so far resemble the sub-
t, as poetry itself ought to resemble na-
e. It should have so much sublimity,
auty, or novelty, as to interest the reader;
d should be expressed in picturesque lan-
age, so as to bring the scenery before his
e; and should lastly bear so much
risimilitude as not to awaken him by the
olence of improbability or incongruity.

With such a wedge driven between the
asoning of science and the visual im-
ery of poetry, we can scarcely be sur-
ised that Erasmus Darwin's metaphors
hich he explicitly places in his visual,
her than his philosophical, world) do
t enlighten his botanical examples.
harles, unencumbered by such an aes-
etic theory, used all the literary devices
his command, including metaphor, to
vance his singular purpose—his "one
ng argument" about evolution.

One other contrast between Erasmus
d Charles should help us to understand
ny Erasmus's heroic couplets have been
rgotten, while Charles's book revolu-
onized human thought. Charles Darwin
so knew about Linnaeus's observation of
merican seeds floating to Norway and
rminating there. He wrote in an 1855
te to the *Gardeners' Chronicle and*
gricultural Gazette: "The seeds which
e often washed by the Gulf Stream to the

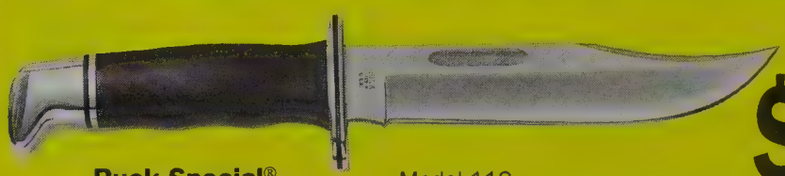
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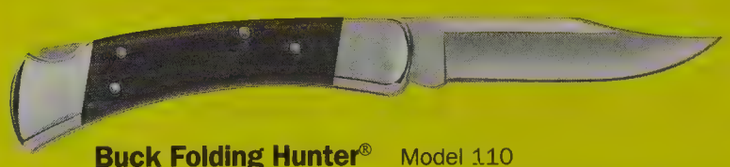
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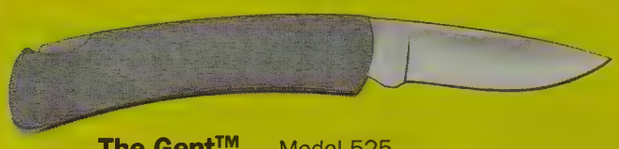
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Rock Bluff, Florida

by Robert H. Mohlenbrock

Originating in southern Georgia, the Ochlockonee River twists and turns through the Apalachicola National Forest in the Florida panhandle and empties into the Gulf of Mexico. The region is primarily flat, with stretches of longleaf pine growing in dry sand above an understory of saw palmetto. But scattered throughout are other habitats—forests of oaks or magnolias, swamps of bald cypress or gum, pond cypress domes, wet savannas, and pitcher plant bogs. A variety of vegetation appears at Rock Bluff, a sandy ridge that runs for a half mile along the east side of the Ochlockonee River. North to south, the ridge rises from thirty to nearly seventy feet, its western side sloping ever more precipitously.

The dry ridgetop, whose lower end is accessible from a small parking area off Forest Highway 390, is massive sandstone covered with sand, which in places is several inches deep. This nutrient-poor soil supports longleaf pine, turkey oak, saw palmetto, bracken fern, and little else. A little downslope toward the river, where there is a measure of shade and some more moisture, the vegetation is dominated by upland laurel oak, sometimes called Da lington oak.

Although the distinction is not co monly made, botanists for years have n ticed that some laurel oaks live in dr sandy, upland habitats, while others live valley bottoms in more moist, shade areas. Florida botanist Robert K. Godfr argues persuasively that two speci

The rare pyramidal magnolia blooms at Rock Bluff in early April.
Steve Orzell



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should be recognized. Among their differences, the upland laurel oak (*Quercus hemisphericus*) has leaves whose lower surface is completely smooth, while the swamp laurel oak (*Q. laurifolia*), has matted hairs on the undersurface of its leaves. While the leaves of the two species are eliptical, the swamp laurel oak, also known as diamond-leaf oak, always has at least a few that are shaped like narrow diamonds.

The upland laurel oaks grow loosely spaced, allowing sunlight to reach the forest floor. The sandy soil is acidic, supporting several members of the acid-loving heath family—farkleberry, deerberry, and Elliott's blueberry. All these shrubs or small trees are kinds of wild blueberries.

The forest elsewhere on the western slopes is a combination of hardwoods and pines, actually an extension of the mixed hardwood forests of the southern Appalachians. Among the species are white oak, basswood, American beech, spruce pine (with short, slender, very flexible needles), and loblolly pine (with larger, thicker, straighter needles).

American holly, with its glossy, spiny-toothed, evergreen leaves and shiny red berries, adds color to the forest during the winter, while red buckeye, flowering dogwood, redbud, and silverbell all bloom in April. The silverbell's one-and-one-half-inch-long, bell-shaped flowers are much larger than those of other silverbell trees in the southern United States. In Robert Godfrey's view, this is a distinct variety limited to southeastern Alabama, southwestern Georgia, and the Florida panhandle west of Tallahassee.

Also flowering in April is the sweetleaf, or horse sugar tree, with its inch-round clusters of fuzzy, pale yellow flowers. The leaf of this species tastes sweet, particularly near the central vein, owing to sugar that the leaf cells manufacture and store. A little later in the spring, the large, white flowers of the shrubby snowbell bush, a first cousin to the silverbell, brighten the midlayer in the forest.

A tree found on the forest slopes is tulip poplar, a member of the magnolia family, whose creamy yellow flowers resemble tulip blossoms. The genus *Magnolia* itself boasts the most spectacular blossoms. Rarest of those at Rock Bluff is the pyramidal magnolia, considered endangered in Florida. The white flowers of this deciduous tree stand erect when they bloom during the first half of April. Southern magnolia, with its large, glossy, leathery, evergreen leaves, blooms in May with the largest flowers of all magnolias—up to ten inches across. Also flowering in May is the sweet bay magnolia, a tree with narrow, white-backed leaves and a rich creamy flower. The leaves of the sweet bay are evergreen in the warm parts of its range, such as Florida and elsewhere in the south, but may be shed farther north where colder winters prevail.

The base of Rock Bluff lies about a hundred feet from the Ochlockonee River whose lazy waters are about 200 feet wide. Blocking access to the river's edge at this location is a streamlike feature, actually an old oxbow of the river. The low terrain leading up to the oxbow is a bog, fed by cool, clear springwater that seeps slowly



Growing on the bank beneath Rock Bluff, a willow frames the Ochlockonee River.
Ed King

ım the base of the slopes throughout the ar. In places, the water may be more ın a foot deep.

Trees shade the bog during the growing ason—sweet gums, river birches, ⁄amp bays, swamp chestnut oaks, and ld cypresses. One mammoth bald cy- ess, whose top was knocked off during a ıst lightning storm, has a trunk twelve et thick at shoulder height. Wetland nes that climb the trees include climbing ⁄drangea, cross-vine, and bamboo vine.

Colorful wetland shrubs in and near the epage bog include dog hobble, titi, and Virginia willow, all with white flowers; deciduous holly with red berries; and two kinds of viburnum with blue berries. Among the wildflowers are yellow star grass of the iris family, and brookweed of the primrose family, and Indian plantain of the aster family, as well as Saint Johnswort and lizard's-tail. Two rarities are the needle palm and the camellialike silk bay shrub.

At least twelve kinds of wetland sedges grow in the bog, along with a few grasses and rushes. Scattered throughout are patches of sphagnum moss and several attractive ferns, from the cinnamon fern with four-foot-long fronds, to royal fern, southern lady fern, southern shield fern, sensitive fern, and netted chain fern. Maintained by the reliable trickle of water, these wetland plants add an extra measure of diversity to the varied vegetation at Rock Bluff.

Robert H. Mohlenbrock, professor emeritus of plant biology at Southern Illinois University, Carbondale, explores the biological and geological highlights of the 156 U.S. national forests.



Rex Rated

Abbott and Costello meet Steven Spielberg

by Roger L. Welsch

By all reports, the recent "Dinosaurs of Jurassic Park" exhibit at the American Museum of Natural History was a roaring success, except that while visitors waited in long lines to peer at the film clips on little television screens, they often passed the authentic dinosaur remains, arrayed nearby, with barely a glance. Such is the phenomenon of *Jurassic Park,* a study in the imaging rather than the science of paleontology. Which means that we can now move into a new interdisciplinary domain, the anthropology of paleontology, or (if I may presume to expand the taxonomy) ethnobonology.

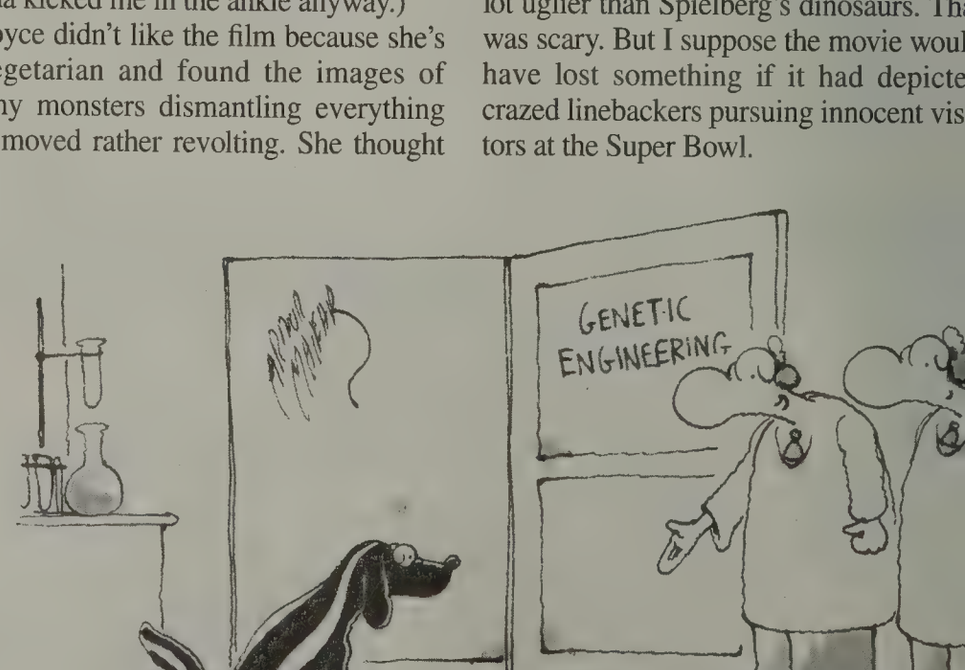
I do not offer myself as a movie critic because I am not much of a movie-goer. Frankly, I don't think much has happened cinematically since *Abbott and Costello Meet Frankenstein,* although I did enjoy the talkie of *Ben Hur.* But at the urging, cajoling, and threatening of my ten-year-old daughter Antonia, we all—Lovely Linda, Antonia, and I, along with my visiting older daughter (and movie fanatic), Joyce—went to see Steven Spielberg's instant classic.

I immediately noted that there have been changes made in movie houses during the couple of decades since my last visit—for example, our four tickets cost just a little more than I paid for my first automobile and not a lot less than I paid for my last one. But I rediscovered my youth in the enduring tradition of greasy popcorn, Jujubes, and Milk Duds, and that's worth a lot. I also took comfort in the fact that fifty years after Abbott and Costello and a hundred miles to the west of the theaters of my childhood, the same obnoxious kids were still sitting in the front row, the same bozo was still hanging his legs over the seat in front of him, and the same lady was still sitting right behind me, kicking the back of my seat throughout the movie and talking about her cousin Marjorie's operation.

To be perfectly honest, I was not at all frightened by the movie. The special effects were pretty good, but a lot of the potential tension was frittered away, perhaps on purpose, in that the dinosaurs were hunting down mostly lawyers and precocious children. It's pretty hard to get worked up about motifs like that (at the point in the film when a cranky *Tyrannosaurus rex* eats a lawyer, the audience cheered wildly, a phenomenon reported from theaters far and wide). Antonia was momentarily shaken when, unseen but not unheard, some voracious predator dinosaurs noisily scarfed down a not-at-all contented cow, but I reassured her that the only place dinosaurs exist is under her bed. (I thought I was pretty funny, but Linda kicked me in the ankle anyway.)

Joyce didn't like the film because she's a vegetarian and found the images of toothy monsters dismantling everything that moved rather revolting. She thought that the plot could have been sustained ju as effectively if raiding herbivores- *Tricelerytops,* perhaps—had been raisi havoc with suburban vegetable garde She took some comfort, however, from m suggestion that she could perhaps look the scenes in which humans were d voured as cases of poetic justice. She lik that.

For me the scariest part was a toss-u On the one hand there was the commerci for Reeboks before the feature started- when did the public start actually payi mountains of money to sit in a theater a watch commercials?—in which profe sional football players slammed the heads (but not their *shoes*) into one a other and made sounds infinitely loud and more brutish than those Spielbe managed to brew up for his bloo thirsties. The football players were also lot uglier than Spielberg's dinosaurs. Th was scary. But I suppose the movie wou have lost something if it had depicte crazed linebackers pursuing innocent vis tors at the Super Bowl.



"We've done it, Rothchild! The perfect watchdog."

The other scary part for me was more incidental. You have to understand that e live in a very small town—about 320 eople altogether. The theater was in rand Island, a town of 30,000, but that is ill a pretty small community. As we shed in our CDs and bought tickets, we countered maybe twenty people we ew—friends and neighbors. We chat-d, compared children, discussed the eather, and reviewed what we had read heard about the movie.

That wasn't the scary part. The scary rt was when the vicious velociraptors d broken out of their pens and were rov-g the grounds of this paleontological nusement park, eating people, tearing em into little pieces, that sort of thing. ut that still wasn't the scary part. The ary part came when some of the main haracters were desperately trying to ade a gruesome death; they were crawl-g in a narrow space in a ceiling of the ain museum building when suddenly a ge, scissor-sharp, meat-tearing reptile aw came ripping through the passage-ay directly before them, nearly tearing a ild in half.

But that wasn't the scary part either. The ary part was when, at that very moment, arol Fanta screamed about three rows be-nd me. I was doing fine up to that point. the preceding hour I had heard lots of nosaurs roar and lots of innocent victims ream, but I had not in my life heard *arol Fanta* scream. I don't blame you for ot understanding, because you weren't ere, but you can take it from me, if I am er attacked by dinosaurs, I want Carol nta right there, three rows behind me. I n writing this three weeks after the fact, d I have still not entirely recovered my notional security.

That's one thing I learned: It's hard to separate this movie, maybe any movie, from its audience. There is no such thing as "the American public." A rural Nebraska public is not, I think, an urban East Coast public. What might terrify a Howard County farmer—a lawyer, for example—probably doesn't even get a rise out of a Philadelphian, and vice versa. As we left the theater, I wondered what the guy with the white forehead and red nose, wearing overalls—obviously a farmer—thought about what he had just seen, an experiment in gene engineering gone berserk. So I asked him. (We do that in Nebraska.) "Well," he said thoughtfully, "this will sure bring about some changes in the cattle breeding industry."

I was reluctant to ask Antonia what she thought because of all the warnings about the kind of trauma a child exposed to such gory violence can suffer. I weighed the issue carefully, but then remembered that the scars I got from *Abbott and Costello Meet Frankenstein* (which I saw *alone*) had pretty much healed by the time I graduated from college. So I asked her. She said that she only closed her eyes during the mushy scenes, that most of the time she was cheering for the dinosaurs anyway, and that for her, the only scary part was when the *Tyrannosaurus rex* was dismantling various herbivores, omnivores, and counselors (again and again, she said, there flashed into her mind the horrible image of the last time she saw me eating spareribs).

My conclusion, therefore, is that you should go ahead and see *Jurassic Park,* if you haven't seen it already. But leave the kids at home—and if at all possible, sit in the back row.

Folklorist Roger L. Welsch lives on a tree farm in Dannebrog, Nebraska.

[*Hillary not included.]

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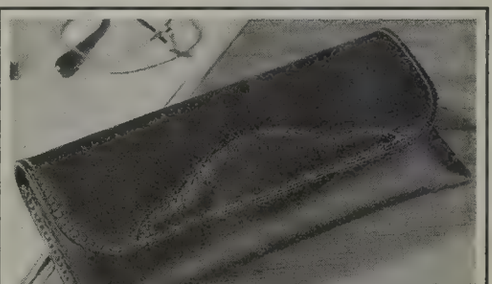
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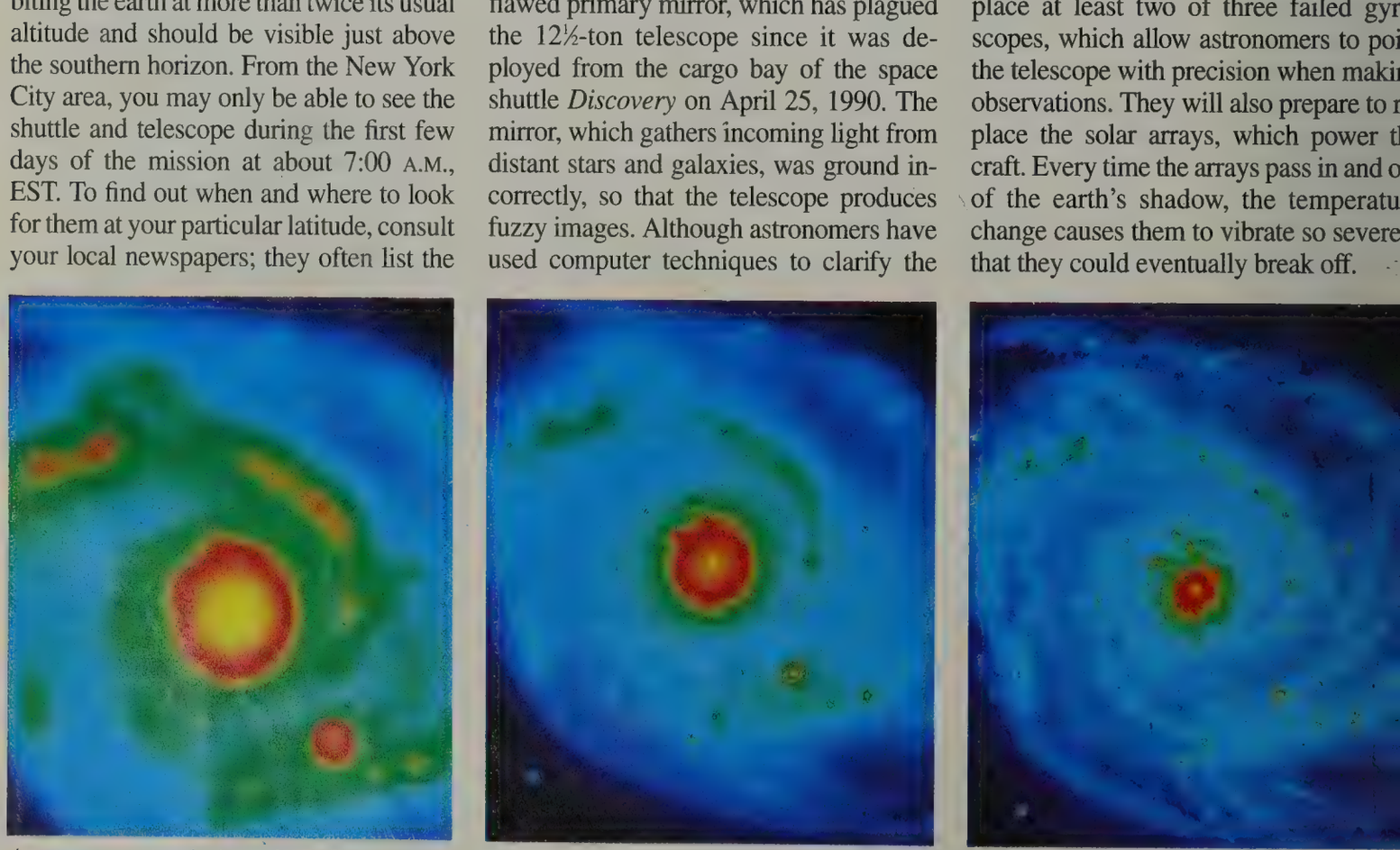
The Big Fix

by Gail S. Cleere

Early this month, if all goes well, you might spot the space shuttle *Endeavour* in its rendezvous with the Hubble Space Telescope 375 miles above the earth. In the hours before sunrise, the shuttle and the telescope will catch the sun's rays and shine with the brightness of a moderate star as they drift across the sky. In orbit, inclined 28.5° to the equator, the shuttle would normally be too far south to be seen from the northern United States. On this mission, however, *Endeavour* will be orbiting the earth at more than twice its usual altitude and should be visible just above the southern horizon. From the New York City area, you may only be able to see the shuttle and telescope during the first few days of the mission at about 7:00 A.M., EST. To find out when and where to look for them at your particular latitude, consult your local newspapers; they often list the dates, times, and locations of the shuttle after a launch.

Endeavour is currently scheduled to lift off from the Kennedy Space Center in Florida on November 30 for a special eleven-day mission. The seven astronauts on board will be engaged in what will probably the most closely watched repair job in history. During five six-hour spacewalks, the astronauts will attempt to install new equipment, including corrective optics to sharpen the focus of Hubble's flawed primary mirror, which has plagued the 12½-ton telescope since it was deployed from the cargo bay of the space shuttle *Discovery* on April 25, 1990. The mirror, which gathers incoming light from distant stars and galaxies, was ground incorrectly, so that the telescope produces fuzzy images. Although astronomers have used computer techniques to clarify the pictures—producing amazingly good r sults that have lead to many new discove ies—only repairs to the telescope w allow it to see extremely distant objec with the sharpness originally expected.

The rendezvous will take place on t third day of the mission. Once the shuttle robotic arm has captured the telescope a secured it in the cargo bay, the astronau will work on the telescope in pairs, alte nating days. When the spacewalks beg on the fourth day, the astronauts will r place at least two of three failed gyr scopes, which allow astronomers to poi the telescope with precision when maki observations. They will also prepare to r place the solar arrays, which power t craft. Every time the arrays pass in and o of the earth's shadow, the temperatu change causes them to vibrate so severe that they could eventually break off.



A computer simulation of a distant spiral galaxy, left, as it would appear from a large, ground-based telescope. Even with its flawed mirror, the orbiting Hubble reveals the same galaxy in much greater detail, center. At right is the improvement astronomers expect to see after the space telescope is repaired.

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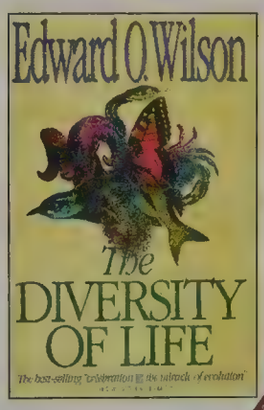


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On the fifth day, the astronauts will complete the installation of the new solar panels, and on the sixth day, they will install a new wide-field planetary camera. On the seventh day, the astronauts will fit the telescope with new corrective "spectacles" (these are actually an assembly of mirrors known as the Corrective Optics Space Telescope Axial Replacement, or COSTAR) and will install new computer memory. During the next spacewalk, Hubble will receive control units for the gyroscopes, and the power supply to the Goddard High Resolution Spectrograph will be repaired. On the ninth day of the mission, astronauts will release the telescope.

Space Telescope Science Institute spokesman Ray Villard is quick to point out that the Hubble team had always planned on the shuttle mission—a regular servicing would be necessary once every two years or half-billion miles, whichever came first. "Even before the Hubble Space Telescope was launched," Villard says, "scientists at the Jet Propulsion Laboratory in Pasadena were working on a planned backup for the wide-field planetary camera, and NASA was assembling a whole inventory of replacement parts to put in when the originals wore out." When NASA discovered the telescope was nearsighted, the first service mission was delayed to work on the corrective optics. "Obviously," Villard explains, "if you delay servicing your automobile for nearly four years, your fix-it list is going to be longer than if you'd done it at two years."

Installation of the corrective optics will restore the telescope's ability to see and pick out individual stars in densely packed star clusters. The optics will also allow the telescope to probe the core regions of distant galaxies and gather enough light to measure the spectra emitted from distant sources.

The Planets in December

Mercury can be seen early in the month near the southeast horizon just before sunrise. As the month progresses, however, the planet moves too close to the sun to be seen.

Venus rises in the east about an hour before sunrise at the beginning of the month, but by midmonth it is too close to the sun to be seen. Venus appears to move in a counterclockwise direction around the sun and will arrive at superior conjunction (nearly in line with the sun) on January 17.

Mars, which is too close to the sun to be seen in December, reaches conjunction on the 27th.

Jupiter is a morning planet this mon rising a few hours before the sun. Just b fore dawn breaks on the morning of t 10th, look above the southeastern horiz for Jupiter, shining like a beacon at –2 magnitude, 4° above the sliver of the wa ing moon. Jupiter passes from Virgo in Libra by midmonth.

Saturn rises before noon in Capricc nus and crosses over the southern mer ian in the evening. By 7:00 P.M., EST, S urn is well placed in the southwestern sk a conspicuous point of light amid fa stars. On the evening of the 17th, Saturn the yellowish white "star" well below a to the left of the waxing crescent moo The next evening, Saturn will be a simi distance away below and to the right.

Uranus and **Neptune**, which can on be located with a detailed sky chart and telescope, are in eastern Sagittarius, whe they share early December's evening ski with Saturn. But they move quickly t ward the southwestern horizon by suns at midmonth. By month's end, Uranus an Neptune are too close to the sun to be see

Pluto, among the faint stars in northe Libra, is a morning object this month.

The **Moon** reaches last quarter on th 6th at 10:49, A.M., EST; is new on the 13 at 4:27 A.M., EST; reaches first quarter 5:26 P.M., EST, on the 20th; and is full o the 28th at 6:05 P.M., EST.

The winter solstice occurs on the 21st 3:26 P.M., EST, the beginning of winter the Northern Hemisphere. The sun cuts i lowest path across the sky and begins i slow trip north, bringing longer days.

The Geminid meteors, the most consi tent shower of "falling stars" so far th year, will peak on the night of Decemb 13–14. These meteors, which averag forty to eighty per hour (for skygaze with access to dark country skies), appe to emanate from the constellation Gemin whose twin stars Castor and Pollux ca easily be seen above Orion's right shou der. The Geminids may be the remnants o an extinct comet, whose core is now th asteroid Phaethon. The shower is be viewed after midnight, when your part o the planet begins to rotate into the oncon ing stream of meteors. The Geminids ar well known for producing an occasiona slow-moving fireball, which can be a spec tacular sight, even from a brightly lit cit Since the moon is new on the 13th an will cast no light, it will not interfere wit sky watching.

Gail S. Cleere lives in Washington, D.C and writes on popular astronomy.



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Hail to Thee, Papa Bear

After the hunt, a Siberian village honors the Old Clawed One

Text and photographs by Alexander Milovsky

"You've been after me for three years to show you an ancient shamanic rite," said the Russian poet Yuvan Shestalov, rubbing his hands in anticipation, "and now we're only a short ride from the village." We had just landed at the airport in northwest Siberia's Khanty-Mansi National District, an oil-rich territory the size of France. Its coniferous forests, or taiga, and vast frozen tundra are the homeland of the Mansi people—reindeer herders who number about 7,000—and of the Khanty, who are about 21,000 strong. These Finno-Ugrian peoples, who live along the northern tributaries of the Ob River, have never been won over to Christianity, Islam, farming, or city life.

A jeep containing our official welcoming committee, including the region's president, rolled toward us across the tarmac. As she greeted us, the president began unconsciously imitating my friend's eccentric hand movements. Yuvan, a native of the region, whispered to me that his grandfather had been a celebrated shaman, and that he, too, had been ordained by the spirits to become one. Instead, I knew, he had attended university in Leningrad (now Saint Petersburg again) and become well known for writing mystical poetry celebrating his Mansi roots. "Each time I come home to this land of the Mansi and the Khanty," he added, "I feel a mysterious power coursing through my veins."

A few hundred years ago, the Khanty and Mansi, then known as Ostyaks and Voguls, had ranged into western Russia, but more aggressive tribes drove them



On the sacred table, above, the head of a recently killed bear is given a hat and finery to wear and is surrounded by the animal's favorite foods. Khanty shaman and hunter Pyotr Yukhlymov, right, carries his ceremonial hoop tied with spirit dolls.



Shaman-poet Yuvan Shestalov, right, goes into a trance in a Sosvinskaya house. Behind him is the table with the bear's head. When it is first brought to the cabin by sleigh, the head, below, is greeted by villagers.





back across the Urals into Asia. In the sixteenth century, during the rule of Ivan the Terrible, the Cossack chief Yermak conquered the vast Siberian lands for Russia. Although all of Russia had officially adopted Christianity in 988, shamanic folk religions prevailed for centuries in outlying districts. Today they survive only among the Siberian hunters and reindeer breeders we had come to visit.

We had traveled to Yuvan's homeland specifically to attend a bear festival, an ancient spectacle that is rare in the modern world. Lasting anywhere from several days to a week, this end-of-winter holiday begins when a hunter kills a bear and the locals decide that they must placate the animal's disturbed spirit. During the Communist regime, this popular folk holiday was banned and its practitioners persecuted or even murdered. Some anthropologists have witnessed public burnings of shamanic outfits and drums by government officials. During my visit, I met several hunters who had served twenty-five years in prison just for participating in the annual bear games. Small wonder, then, that until very recently bear fests were held only in the remote taiga, and shamans practiced their "seditious profession" in secret.

Over the years, only the most persistent, dedicated anthropologists have gained access to bear fests. Most prominent among them was Russian ethnographer Valery Chernetsov, who lived with the Mansi during the 1920s and 1930s and published descriptions of the bear fests he attended. For three years I had waited to witness one, intrigued by the idea that this ancient tradition may have survived, unbroken, since the days of the Ice Age hunters. When Yuvan was notified that a bear had been killed near the taiga village of Sosvinskaya and that a bear fest would soon follow, we boarded the first plane to th Khanty-Mansi region.

At the little airport, Yuvan and I rente a reindeer-drawn sleigh and driver to tak us from the airport to the village, whic straddles the western tributary of the O River. As the sleigh's metal runner crunched along the thin, icy snow crust, remembered a passage from Leo Tolsto who had been impressed by an account c "the theater of the savage Voguls," the ol



erm for Mansi. He recounted how one ribesman, a big man, took the part of a oe, while a smaller man played its calf:

A third Vogul played the part of a hunter. He eld a bow and arrow and had snowshoes on is feet. A fourth depicted a bird that varned the reindeer of danger. The hunter talked the doe and its young relentlessly. That, indeed, was the drama of the piece. The deer ran off the stage, then came running back. The performance took place in a mall yurt [a conical tent supported by latticework]. The hunter came closer and closer and wounded the calf. Exhausted, it pressed up against its mother, who licked the wound. The hunter drew a second arrow. The audience, as those present related, held its breath. There were sighs of sympathy. Someone even sobbed. This description brought home to me that this tribal pantomime had been a true work of art.

We arrived in the village to find many people preparing food and costumes for the festival, and the next few days lived up to my expectations. There were rituals, dances, and pantomime plays galore—most of them on hunting themes or having to do with animal spirits. True, there were no longer any yurts, or, more precisely, no more *chums*, the portable tepees made of deerskins. Nowadays, the local people live in Russian-style log houses—some of which were given over to the rituals and performances.

Most family-owned herds of reindeer



have long since been integrated into communally owned herds, and many people have settled in small collective villages. Some have managed to retain small private herds, which they work in addition to tending the collectivized deer—but there were none so fortunate among the people we visited. Ethnographers report that a few families still move between the tundra and the villages, depending on the season. But many thousands, long prevented from effectively expressing themselves politically, and now without herds of their own, feel deprived of the foundation of their economy and culture. The reindeer gave them their clothing, food, housing, and transportation.

Oil and gas companies have increasingly driven these once nomadic herders off their traditional lands and into the marshes. Their brightest young people have been offered scholarships to Moscow University and jobs in the oil industry, but the only thing most of them want—the reindeer-herding life—has been forbidden to them. Many Khanty and Mansi are addicted to alcohol, and the group has a high suicide rate. Whole communities have degenerated from imposed poverty; those who can hunt live by poaching fur-bearing animals. At bear festivals, however, the often gloomy villagers have a genuinely good time; the holiday atmosphere buoys their spirits and reminds them of a happier period in their history.

The bear fest, which is believed to foster a successful hunting season, begins with two or three days of preparation and may last anywhere from one to four days. Sometimes as many as nine reindeer from the herds are sacrificed (if the people can afford such extravagance), and on the last day of the festival there may be an all-night marathon of dancing and singing sacred ancestral songs. Many of these recount the origin of mankind, which is linked with their legends about bears. Khanty and Mansi have social-kin groups, known as the Por, whose ancestors received fire and weapons from the legendary Konsyg-Oik (Old Clawed One), the world's first bear. Konsyg-Oik's father, Torum, the highest deity in Khanty and Mansi mythology, allowed him to enter the world of men.

Bear festival celebrations I attended were held in the large house of one of the hunters. Its big room was cleared of all furniture, and a "sacred" table was placed in the front corner. Ornamented birch boxes, artifacts made of deerskin, and bright, sequined articles—the essential accoutrements of the holiday—had been borrowed from all over the village to decorate the room and table. A collection fit for an ethnographic museum was on display, including a ritual bear cradle, carved wooden plates, and a magnificent *sankvyltap,* or sound-maker, a traditional Mansi musical instrument with strings made of reindeer tendons. (Similar to Finnish and Estonian *kanatele,* the *sankvyltap* resembles the old Russian psaltery. No bear festival passes without *sankvyltap* music. According to Mansi folktales, anyone who plays this magical instrument becomes all-powerful. The hero of the Karelo-Finnish epic *Kalavala* played the miraculous *kantele* and was helped by his songs to creat the world, to build the first boats, and t defeat evil spirits.)

Twenty to thirty people of all ages wer gathered in the house, and many mor were outside, all in holiday dress. The ol men sat in silence, puffing their pipes They unbuttoned their dark jackets, re vealing the yellow or red silk of thei loose, embroidered shirts girded wit braided cords. In olden days, the linen fo jackets was homespun; nowadays the ma terial is factory-made, but the cut is stil traditional. Women wear long, brightl colored, loosely hanging dresses, with em broidered borders and gathered yokes an cuffs. Mansi outer garments, especiall the fur coats, are well made. So is th footwear—the *torbassa* fur boots and th soft *kees,* which are high deerskin boot ornamented with *kamous,* the fur of th reindeer's legs.

Women had spent several days prepar ing food for the celebrants, and the aroma of their cooking filled the air. When it wa time for the guest of honor to arrive, a



Inside the cabin, celebrants wearing masks and costumes of animal spirits, left, perform holiday pantomimes, dances, and skits. Below: Later the festivities move outdoors, where the sacred table is reestablished, and hot cocoa is served.



ledge carrying the head of a dead, but as et unconsecrated, brown bear pulled up o the porch of the house. More than a hun-lred people, or half the village, had gath-red to bid the bear-spirit welcome. Seven hots (a mystical number) rang out, and nowballs flew in every direction, for peo-le were supposed to sprinkle each other vith water or snow for purification. After ll, the holiday was for no ordinary beast, ut for the powerful ancestor who could e reborn after death. Indeed, purification s an essential element of the bear fest, be-ause the soul of the killed bear might arm people if it were not placated.

All possible honors were accorded the ear's head; people bent over it to say arewell. After it was taken carefully out f the sleigh and passed from hand to and, men jostled and wrestled beside the oor for the privilege of carrying it into the ouse. Indoors, it was placed upon the sa-red table amid the food—bread, cookies, andy, fish, and deer meat. A saucer of moldering *tchaga,* a medicinal birch tree gall that is heated but otherwise un-processed, is also part of the purification.

The seats of honor at either side of the head are traditionally occupied by the shaman and the hunter who killed the bear. Although a headdress of leather fringes covered his face, I immediately recognized my friend Yuvan wearing the shaman's outfit. While it was strange to see a renowned urban poet playing the tribal role, I realized it was not inappropriate. Yuvan's poetry is based on mystical themes, and his prestigious shamanic family background was known to all in the village. On his right was Pyotr Yukhlymov, one of the village's best hunters (and also a shaman), who had accounted for many bears. Farther along the wall sat Yukhlymov's helpers, musicians, and onlookers. The middle of the room was left free for skits, songs, and dances.

Suddenly Yuvan took up a frame drum and beat upon it, gradually increasing the tempo. As he stepped into the middle of the room, the sacrament of the ancient dance began. Yuvan's movements became more agitated as he entered his deep trance, and "flew" to other worlds, where he contacted the spirits. Onlookers froze in apprehensive expectation. Would the powerful spirits come to their aid or thwart their requests for a prosperous hunt? In due course, the shaman's movements and strokes of his frame drum slowed down. The spirits had agreed to help the people, and he was returning to this world.

Next came the hunter's turn. Pyotr Yukhlymov had vanquished the animal and was the leading performer of ritual songs at the bear festivals. He was the first to apologize to the bear's head and to beg its forgiveness. In so doing, he rose to his feet, bowed, and said, "Forgive me—I didn't kill you, it was the gun. Others [that is, Russians] made this gun. We didn't mean to kill you. We'll never do it again."

Under the accusing eyes of the shaggy head, the other hunters affirmed their colleague's innocence in its death. Yukhlymov then sang a long, doleful hunter's song, whereupon three hunters joined hands and performed a ritual dance depicting the bear's life in heaven and on earth

A fur-clad man, villagers portrayed as athletic high-spirited "bear games," accompanied by accordion music.



A long time ago, when people had not yet learned to make fire, the bear had lived with his father, the Great Torum, creator of the world, beyond the clouds in seventh heaven. Seeing the earth from above as it changed color with the seasons, the bear learned to live there rather than among the stars. He begged his powerful father to let him descend, until the latter gave in and lowered him to earth in a cradle. Soon, the bear was hungry and asked to be taken back to the stars. But instead, his father gave him a bow and arrow and fire and told him to live on earth and learn to make his living there.

Torum also told his son to establish law and order on the earth, and to treat evildoers harshly. He warned that if he wronged people, they would punish him. The bear ignored the warning and created much trouble, whereupon one of seven brothers killed him, took away his bow and fire, and gave them to humans.

Mansi dancers portrayed in great detail how the first bear was stalked and untracked, and how seven arrows were needed to bring him down. Accordingly, the magical number seven is prominent in all the rites, a reminder of the seven major stars in the constellation of the Great Bear (Ursa Major) in the heavens.

The traditional ritual play about the first bear was followed by a dress performance of masked and costumed dancers, the accordion offered musical background for the cavorting figures. Wearing birch-bark masks with long, slurry noses, they twisted and turned, tackled and chucked, and mimicked a hunter setting traps, a fisher pulling out a net, and various other activities of the taiga, from reindeer to monsters. Archaic elements mingle with the contemporary, and religious songs alternate with comic skits that ridicule clumsy hunters caught in their own traps or fishermen who fall into the holes. In a village where everyone knows everyone else, the actor's allusions to such incidents are no riddle, and general laughter broke out again and again.

The bear games have a traditionally established order, but participants, as in any other folk holiday, are allowed to improvise, to make up scenes and skits, and to insert new jokes and satires. They poke fun at issues of the day, lampoon political leaders, and connect ancient rites with present-day life. Some of the traditional satires were blatantly anti-Russian, mocking priests, traders, and administrators.

Only men took part in the dress performance, while women enthusiastically participated in the mixed dancing that followed. Local celebrities, first adults and then the young, sang to the accompaniment of stringed instruments. According to American anthropologist Marjorie Mandelstam Balzer, bawdy dancing and gender reversals may be included in the traditional ritual dramas, with males traditionally taking women's parts in the plays and being uninhibited in their female impersonations, but I did not witness this. Women not only danced but also participated in the ritual greeting of the bear.

As the day wore on, the revelers moved outside. Yavan put a match to the straw tail of a man wearing a long birchbark snout—a fox spirit—who rushed out of the house yelling loudly and calling for everyone to follow. In Mansi folklore, the red fox represents fire, which was given to mankind by the son of Torum. In the large, snow-covered yard, appetizing bear and deer meat was being boiled in pots over open fires.

Emerging into the cold from the warmth of the house, the merrymakers lost none of their exuberance, and the show continued, as "reindeer" in pink dresses galloped in a circle within the ring of onlookers. Nikhlamov pretended to shoot an arrow from his bow, and an "elk" in a red silk shirt dropped to the ground.

The bear's head, which had also been brought outdoors, lay on a table amid plates of cooked fish, steaming meat, and other dishes made for the holiday gathering. The fear-inspiring head, it seemed to me, had grown kinder after the day's rites, apologies, and treats. No longer was it angry at the humans. Revenge was furthest from its thoughts, which meant that the bear festival had been a success. □



Last Stand in the Sand

Time is not on the side of arthropod survivors in the Florida scrub

by Mark Deyrup and Thomas Eisner

Sand is the very symbol of transience. Wind carries it off, waves wash it away, and it is constantly running out in the hourglass. Rock is a trustworthy foundation, while sand dunes are inherently shifty. One would not expect to find the final refuge of an ancient and once great ecosystem in a pile of loose sand. Nature, however, can ignore our preconceptions.

Over millions of years, climatic changes have swept back and forth across North America, bearing with them whole ecosystems. During the late Pliocene and early Pleistocene, some 2.5 to 1 million years ago, much of North America was covered by warm, dry savanna and was home to a spectacular array of large vertebrates (now known only from fossils) that in some ways resembled the fauna of the African veld today. These prehistoric North American camels and horses, ground sloths and elephants, must have shared the landscape with an equally diverse assemblage of plants and arthropods (creatures such as insects, spiders, and mites). In the late Pleistocene, North America went through a series of cold and hot climatic crises that tumbled the regional biota about like a malaria victim's blankets. Today, little is left to remind us of the earlier dry-land ecosystem, especially in present-day eastern North America, which is largely wet, cool, and forested. Nobody is going to find a remnant of the savanna, some little island that time forgot, stocked with early horses.

Early horseflies, however, are another matter. Relict animals, survivors from an earlier time when they were widespread, do exist on a small scale. They are not hiding out in literal islands, but inhabit ecological equivalents of islands—patches of the once great Pliocene savanna. This habitat, called the Florida scrub, is a series of sand ridges, which drain water so quickly and thoroughly that they foster a dry-land habitat during wet as well as dry eras. Perched on and burrowing within the ridges, relict arthropods, such as the nonbiting *Asaphomyia* horsefly, find a sanctuary in the sand. At the Archbold Biological Station in south-central Florida, we have spent more than ten years catching, observing, and photographing the local arthropods—and looking for larger ecological and geographic patterns that drive life in the Florida scrub.

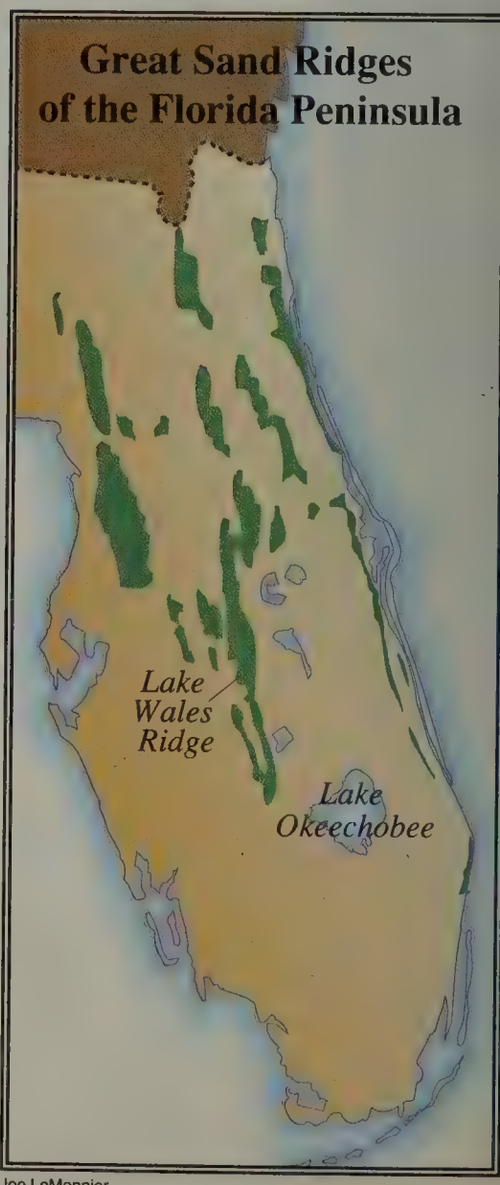
For small creatures, sand holds hazards unimagined by beach bums, and scrub arthropods have evolved adaptations to deal with the physical dangers of life in the sand. Small organisms have a very large surface area in relation to their body volume, and arthropods are therefore in constant danger of drying out. A thin layer of protective wax over the body surface is usually sufficient to prevent desiccation, but travel through sand can abrade the wax layer, and if the sand is dry, the arthropods are in serious trouble. (Ancient Romans are said to have exploited this phenomenon; by mixing fine road dust with stored grain, they helped prevent infestation by insect larvae.) Thus, burrowing scrub arthropods tend to be heavily armored and are often hairy as well.

The hairs keep sand off the surface of the body, protecting the indispensable wax; since these hairs usually point backward, they allow the insect to make head-

The sand ridges of the Florida scrub, below, are home to shrubby plants, birds such as the Florida scrub jay, and sand-loving insects, including the short-horned scrub grasshopper, right.

Reed Bowman





Joe LeMonnier





ationed in the middle of her orb web, ft, an Argiope *scrub spider awaits sitors. The reflective, silver white color these spiders may be an adaptation to e dry, open, sunny habitats they prefer.*
otographs by Thomas Eisner

By night, the caterpillars of the Nemoria outina *moth feed on the leaves of scrub rosemary. By day, these masters of camouflage stand rigid on their hindmost legs, mimicking either the rosemary's green, smooth leaves, below, or its gray, knobby twigs, bottom.*





vay in loose sand and resist constantly lipping backward in the same way that a adminton birdie resists being pulled ackward out of the net. In some species f hairy, sand-loving ant lion larvae, the airs point forward while the insects move ackward through the sand. In addition to nt lions, remarkably furry sand roaches nd June beetles inhabit the Florida scrub.

While the tenant of a sand castle needs short lease, the inhabitant of an under- and labyrinth can expect considerable tability, even when drastic things are hap- ening overhead at the surface. Pressure rom above is unlikely to collapse small unnels and chambers; sand grains brace ne another and exert pressure laterally as vell as downward, so that force directed rom above is rapidly diffused. Rainwater noves easily down through the sand and nay seep into the living quarters, but it drains away again just as readily. Above ground, the scrub is open and exposed, ubject to rapid shifts in temperature and umidity, but the sand is so permeable that burrowing arthropods can easily find their preferred temperature and humidity levels by moving up, down, and sideways in their andy element.

Scrub arthropods have taken to this deal home-building medium with vigor nd with a variety of excavating tools. Scrub wireworms (beetle larvae), which re usually both well armored and hairy, an pull themselves through the sand with tout legs or wriggle forward with their vhole body. The sand roach, convex bove and flat beneath, can swiftly bury it- elf like an asymmetrical wedge, driven lownward by broad, spiny legs. Harvester nts haul up big sand pellets from their hree-foot-deep nest, using a kind of bas- et made by a ring of long, curving hairs extending down from the mandibles and nderside of the head. We have even dis- covered a new little species of scarab eetle for which sand is such an ideal ele- ment that the creature never seems to emerge. Blind and wingless, with a heavy carapace and hairy belly, this beetle spends its life digging with the heavy, clawed limbs of a minuscule mole.

Although not so absolutely subterranean as this scarab, many other scrub arthropods carry on the full range of life activities beneath the surface. Caterpillars and beetle larvae forage about the roots of plants grazing on the fine rootlets. Troops of termites maneuver subsurface to find partly buried twigs and dead leaves. Predators find it equally easy to hunt their prey below ground. While a graduate student at the University of Florida, ant specialist Catherine Thompson found that a perforated vial with a meat bait buried at random in the sand quickly attracted tiny, pale yellow predatory ants that apparently hunt freely through the sand.

Minute, young, predatory larvae of bee flies and robber flies slip through the silica, searching for grubs and clutches of grasshopper eggs. The scrub is also the home of a great assemblage of hunting wasps. Each drags its special prey to a burrow in the sand, while constantly guarding the kill against agile, harassing scavenger flies—replicating in miniature the vanished mammalian hunting scenes of the ancient Florida savannas. Nighttime offers no relief for the edible, for that is when wolf spiders emerge to stalk anything moving on the surface.

This profusion of active hunters is unusual for eastern North America. Elsewhere in the east, we find that the overwhelming majority of "top dogs" of the insect world are parasitoid wasps, particularly those known as ichneumonids and braconids. These wasps lay eggs on or in their prey, and a wasp larva usually develops quite slowly as it consumes its living host. This strategy works well in areas of dense vegetation and heavy soils, where the parasitized victim is hard to find, but in the predator-filled sands of the scrub, and in the open vegetation that sand supports, a weakened, parasitized arthropod is likely to be quickly picked off by predators. In this way, sand has changed the character of the food web.

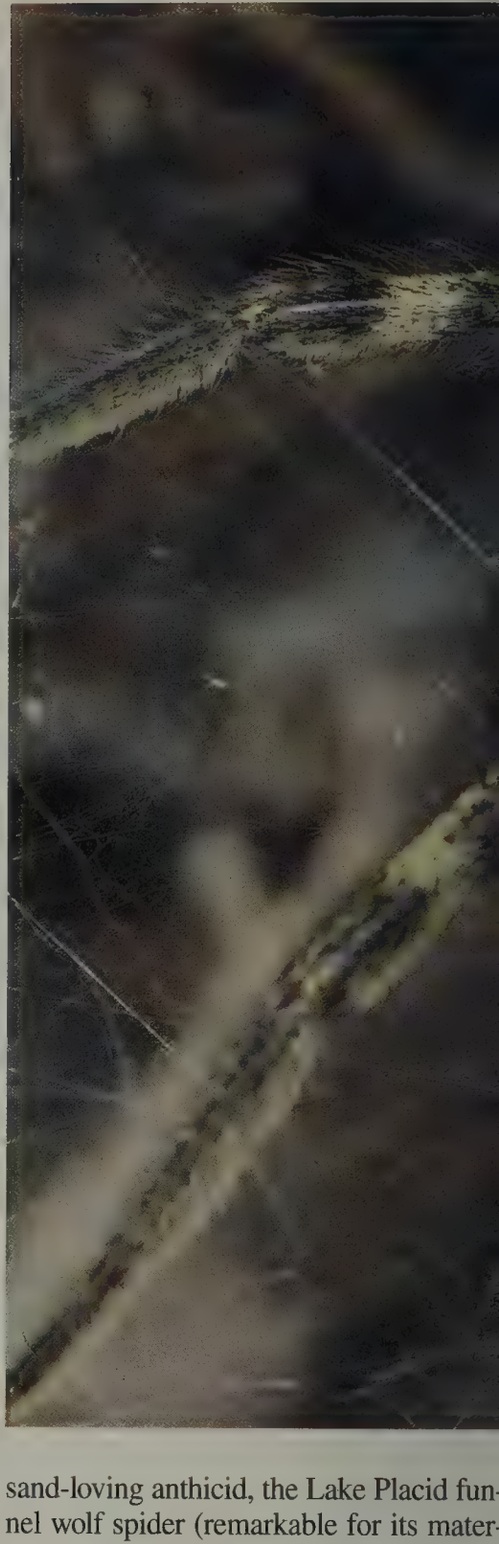
Many arthropods are indirectly dependent on the sterile, droughty sand of Florida scrub because they feed on plants that live nowhere else. Scrub plants tend to have tough, leathery, waxy, and often hairy leaves, all features that enable the plants to conserve water by retarding evaporation from their leaves; these features also reduce palatability.

In addition to these incidental physical defenses against herbivores, a relatively large proportion of scrub plants have high concentrations of insect-repellent chemicals. Possibly the sterility of the soil and the consequent difficulty in accumulating the nutrients needed for plant growth have selected for plants that are chemically protected against most herbivores. But how

The forward-projecting hairs on an ant lion larva's head and mandibles, below, afford protection from struggling prey and help the larva smoothly drag its victim under the sand. At right, a female Lake Wales Ridge wolf spider faces one of her offspring. Spiderlings usually hide in an underground burrow but emerge when prey blunders into their mother's trampolinelike web.

Photographs by Thomas Eisner





ily defended plants often have specialized natural enemies that can bypass defenses, just as there are thieves that specialize in safecracking.

Scrub rosemary, for example, is host to its own coterie of insects. (The common name of the plant is derived from its pungent odor and needlelike leaves; it is not related to culinary rosemary, and we suspect its addition to a pot of stew would be unpleasant or toxic.) This plant has the unusual distinction of having its own species of grasshopper. One of the few grasshoppers dependent on a specific plant, this insect belongs to the same genus as the African plague locust, a notorious species that attains the height of omnivory when it eats cotton garments off the clothesline. Scrub rosemary is also attacked by a specialized moth, whose caterpillar stage is so exquisitely versed in the art of camouflage that it has a gray knobby winter form (like a dead rosemary twig) and a smooth green summer form (like a rosemary needle). We have found other moths, beetles, and sap-sucking insects on scrub rosemary and believe that most of these are likely to be totally dependent on the plant.

Many hardships, such as those imposed by plant defenses and by the physical properties of sand, present evolutionary challenges. Florida scrub habitat is filled with hundreds of species of arthropods that have met these challenges because they have had a very long time in which to do so. For these arthropods, however, "time that gives doth now his gift confound." Their habitat, once widespread, is now restricted to the crests of a series of ridges, many of them small. The specialized scrub organisms thus find themselves in much reduced circumstances, confined to an archipelago of discrete "islands" of habitat. Time is clearly not on their side. One might ask, with Robert Frost's ovenbird (a frequent winter resident in Florida scrub), what to make of a diminished thing. The answer is that a diminished thing can be singularly fascinating.

The evolution of distinctive forms of life on separate islands is a phenomenon that has served as a fount of evolutionary insights since Darwin and Wallace propounded their theories of natural selection. Today, the arthropods on "islands" of scrub are providing some illuminating examples of evolutionary divergence in groups such as wolf spiders, scarab beetles, and short-horned grasshoppers.

The Lake Wales Ridge, for example, is a long narrow "island" whose remaining patches of scrub habitat are home to arthropods found nowhere else. These include a newly discovered species of a tiny, sand-loving anthicid, the Lake Placid funnel wolf spider (remarkable for its maternal care), and a large, burrowing scrub millipede that has no known close relatives. Earlier studies of plants confined to this area had already identified the Lake Wales Ridge as a center of endemism, a circumscribed area graced by an abundance of species that evolved in that place and are unique to it. Such centers of endemism are highly vulnerable; if the habitat disappears, the species are lost with it. The Lake Wales Ridge has therefore become a prime area for habitat conservation proposals, and if these proposals succeed, numerous plants and animals, including many scrub arthropods whose endangered status is not even known, would have secure futures.

The special status of the Lake Wales Ridge is well known, but many other is-



nds of scrub habitat have not been studd methodically. This may seem surprisng in a state as populous as Florida, but ne number of explorer-naturalists availble is inadequate for so large and diverse state—a problem by no means confined Florida. To make matters worse, the differences in a type of plant or animal from ne scrub island to another may not be onspicuous, or the significance of these ifferences may not be clear. Plants, in articular, are so responsive to annual uctuations in weather and to herbivore bundance that controlled growth experiments or genetic analysis may be needed show that a population is highly distinve and should be recognized and proected. The pace of this research is vastly lower than that of bulldozers erasing the crub. Into this scene of taxonomic confuion and conservation trauma, the short-horned scrub grasshoppers of the genus *Melanoplus* leap to the rescue.

These small, flightless, *Melanoplus* species that inhabit Florida scrub are attractive creatures with an alert stance, a black racing stripe, and a freckled face. Their most interesting feature—for both biologists and female grasshoppers—are the male grasshopper genitalia, including some rather complex inner structures and a pair of external appendages called cerci, which may be strikingly modified as claspers. Although these grasshoppers are all superficially alike, the male genitalia can be remarkably different, and these differences can be observed instantly with no equipment other than a microscope. This allows us to arrange most of peninsular Florida's scrub ridges into five major systems. Our hypothesis is that where an isolated species of scrub grasshopper exists, every other scrub species (both plant and animal) whose dispersal is no more efficient than that of a flightless grasshopper has also been isolated and is likely to be genetically distinctive.

We are just beginning to see some major themes and patterns in Florida scrub. The fascination of nature is in the details, and the interactions and coevolved relationships between many scrub species are still waiting to be discovered. An added incentive for prospective researchers is that the arthropods of Florida scrub are a sure cure for mental myopia. One cannot think logically about these organisms without dizzying transitions of scale, from phenomena associated with a grain of sand to those continental in scope, and from the time since the passage of the last rain to events hundreds of thousands of years in the past.

It's time for a change to Gallo.



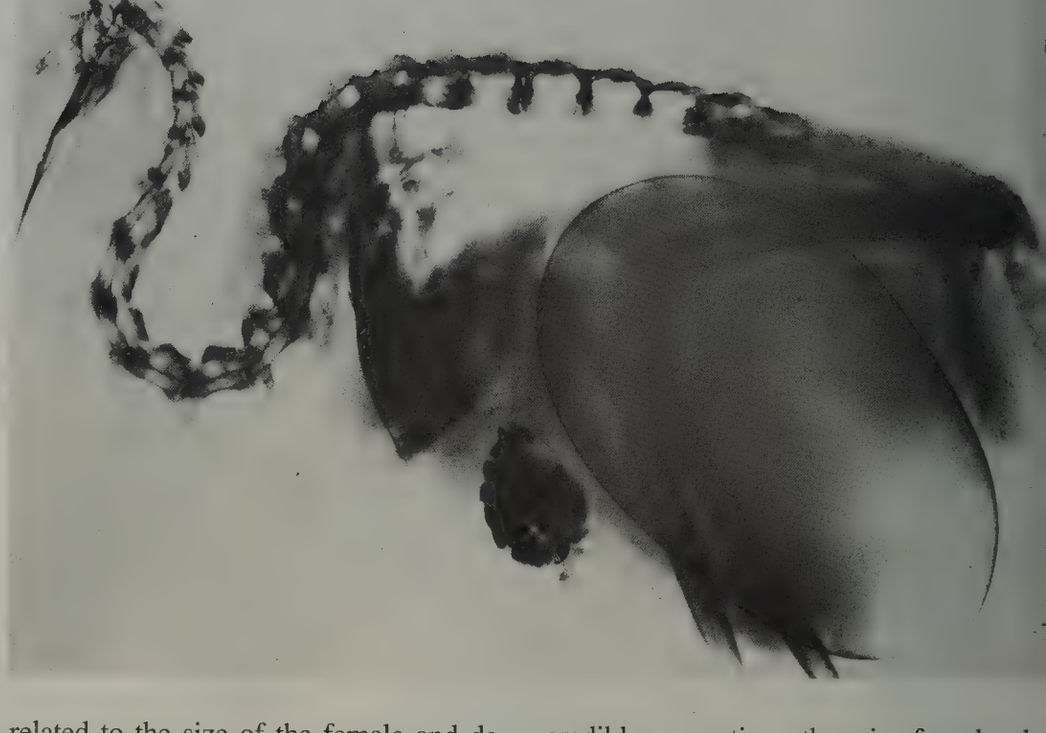

THE WINE CELLARS OF
ERNEST & JULIO GALLO
CABERNET SAUVIGNON
OF CALIFORNIA

Rod Morri

The Kiwi's Parental Burden

Reproduction is a big event for New Zealand's "honorary mammals"

by Michael Taborsky and Barbara Taborsky



An X-ray, below, reveals an egg, ready for laying, in a female brown kiwi's oviduct. Some thirty days in the making, the one-pound egg is more than 60 percent yolk. The father will incubate the egg for more than eighty days. Right: At New Zealand's Mount Bruce captive breeding facility, kiwis are provided with burrows in which to care for eggs and young.
Barry Rowe; Otorohanga Zoological Society

Imagine that your breakfast egg weighs more than a pound and that this super-ovum is fully three-fifths yolk. You might suppose that the producer of such a calorie and cholesterol bomb would be an ostrich. Yet the bird that lays such an egg, the brown kiwi, is just slightly larger than a domestic chicken. It is a member of one of three species of kiwis, all flightless and nocturnal, that inhabit the evergreen forests of Northland, on New Zealand's North Island.

Kiwis are renowned for their extraordinary features. They are the only birds whose long bill is literally a nose. The nostrils are situated near the tip of the bill, enabling kiwis to smell out and uproot earthworms and other soil organisms, their primary food. Their highly developed sense of smell and hearing, their furlike feathers and low body temperature, and other physiological specialties have led scientists to award these birds the status of "honorary mammals." But the focus of our studies has been the brown kiwi's remarkable mode of reproduction. Since 1985, we have followed a population of these endangered birds in the Waitangi Forest of Northland.

In general, egg mass in birds is strongly related to the size of the female and declines allometrically as her body mass increases; that is, egg size doesn't keep pace with body size. The tiny hummingbirds, for example, produce eggs weighing about 15 percent of their body weight, while the largest living bird, the ostrich, lays an egg weighing only 1 or 2 percent of the female's mass. The three-pound ostrich egg is tiny when compared with the 300-pound bird that lays it. According to the usual relationship, we would expect our Waitangi kiwi females to lay eggs weighing about 4.2 ounces. But instead, they produce eggs of one pound on average, almost four times larger than expected and almost 17 percent of the female body weight of about six pounds.

These eggs are not only huge but they are also more than 60 percent yolk, an incredible proportion otherwise found only in megapodes (an unusual group of birds, including Australian brush turkeys and mallee fowls, which do not warm eggs with their body heat but use natural "incubators" of rotting leaves, hot sand, or volcanic warmth). Kiwis are also ground nesters, laying their eggs under rotting vegetation, in a clump of grass, under pine needles, or in burrows, but unlike megapodes, they must physically incubate their eggs for the embryo to develop. At the time of hatching, a third of the mass of the kiwi chick is still yolk. For the first two or three days after hatching, the plump young cannot stand up because their legs are spread so wide by the big yolk sac enclosed in their belly.

This jumbo egg also requires the longest incubation period known among



Bill Noel Kleeman

Flightless, with mere remnants of wings, kiwis have sturdy legs, below. An adult can scramble through forest undergrowth, right, about as quickly as a person can run. Until non-native predators such as dogs were introduced to New Zealand, kiwis' size and nocturnal habits afforded the birds adequate protection against any dangers in their environment.

Oil painting by Ray Harris-Ching





birds. The kiwis we studied spent an average of eighty-three days incubating each egg, almost twice the amount of time that we would have expected, given their size. The oddities do not end here. Only the males spend this vast effort in time and energy. Waitangi male kiwis spent ninety-one days incubating before the second chicks of the two-egg clutches hatched, and another week or two brooding the young. A male will sit on the nest almost around the clock, leaving it only to search for worms and arthropods for a few hours each night. Luckily for the males, after the first few days, the chicks "get their legs" and become self-reliant. A week after hatching, they can sniff out food on their own, and they return to the burrow only to be warmed by the male during the day and part of the night. Males can then slowly begin to recover the more than 20 percent of body weight they have lost; by this time they look quite miserable.

What do kiwi females do while their partners are nest-bound for three months? Why don't they share in incubation?

In birds, the mating system—whether polyandrous, polygynous, or monogamous—usually correlates strongly with the relative amount of effort males and females put into producing and raising their offspring. In those species in which the males alone care for the young, the female is usually polyandrous; that is, she goes on to mate and lay eggs with other males during the same breeding season. With the males nest-bound for months, and the females free after laying two eggs, female kiwis have a high potential for polyandry. And in Waitangi, polyandry is especially likely because of the biased sex ratio. For every female, 1.4 males inhabit the Waitangi Forest. Like paired males, some of the surplus males are territorial, but they use areas of more than thirty acres, twice the size of, and extensively overlapping, their paired neighbors' ranges. Other bachelors roam vast areas that overlap several male and female territories. Thus, males seem to be readily available for any female looking for a second mate.

To find out whether females were indeed polyandrous, we attempted to follow their movements. This was no easy task. These purely nocturnal birds inhabit forests and swamps with dense undergrowth, so we could observe them only indirectly, primarily through radiotelemetry. Catching kiwis is an adventure, taking place at night in dense bush where orientation is accomplished mainly by ear. In our study area, primarily pine forest, the most efficient way to proceed was just to run after the birds and grab them by hand. More often than not, *we* got caught in thick undergrowth, trapped by a thorny "bush lawyer" (a vine that takes you in painful "custody"), stumbling over half-rotten tree stumps and falling into hidden pits—without even catching sight of the bird we were chasing. Often only through some mistake on the part of the pursued bird were we able to get hold of it. We then attached a transmitter to its leg with flexible bands, the type used as name tags for hospital patients. These bands tear after a month and release the transmitter; this is important if the transmitter fails, so it will not encumber the bird. The individual signals emitted by each transmitter allowed us to locate the bird at any time of day.

We also weighed females regularly and



urveyed nests where eggs appeared after a female had been found ready to lay. In not a single case did a female lay for a male other than her mate, with which she shared most of her home range.

We further checked kiwi faithfulness by determining the genetic similarity between offspring and the presumed parents. We sampled small amounts of blood from the leg vein and used DNA fingerprinting and analyses of specific enzymes. This allowed us to determine the parentage of chicks and confirmed that females are faithful to one partner.

If the female kiwi is not laying for another male while her partner tends the nest burrow, is this because she needs time to recover from the rigors of producing her giant eggs? To answer this question, we measured the amount of both time and physical energy the female expends in breeding. By regularly weighing females, we were able to note when their weights started to rise as a result of "pregnancy." We learned that thirty-four days were needed to build an average egg—another world record. Most birds take only one or two days for this task, and only in a few rare cases is a week required. But compared to the kiwi male's hundred-day bondage to the nest, during which it hardly ever feeds, the kiwi female's investment is rather modest.

To determine the total energy expended by females, an estimate of the energy expenses of producing eggs is added to their caloric content. We contrasted this investment with that of the male. For his contribution, we gauged egg, nest, and ambient temperatures, and estimated the energy needed to heat the clutch and keep it warm. We also quantified daily energy expenditure by injecting individual kiwis with doubly labeled water and measuring the decline of certain isotopes after the bird was recaptured. Estimates, based on all these techniques, suggest that keeping eggs warm until hatching is slightly less of an energy drain than producing the clutch. However, because of reduced feeding time, the males lose a similar amount of weight during incubation as females do during egg laying.

We did discover that mate fidelity was not the result of the females' inability to lay more than two eggs in a row. Three of our females produced a third egg, one of them even a fourth. Their sizes did not differ from those of the first two eggs and the interval between the second and third egg

Kiwis have a highly developed sense of smell. The nostrils at the tip of their long beak enable the birds to sniff out soil-dwelling prey, below. Kiwis, particularly males, defend their breeding territories. When fights break out, right, the primary weapons are strong legs and long claws.
Pencil drawings and oil painting by Ray Harris-Ching



was not longer than that between first and second. All three females laid these extra eggs for their one and only partners in cases when the males had not accepted the first nests and clutches; in other words, they were replacement eggs.

With free time after laying and the capacity to lay more than two eggs in a row, and with males taking the greater share of reproductive costs and plenty of surplus males around, why do female kiwis not produce a clutch for at least one additional male? Do we have to abandon current evolutionary theory to understand kiwi behavior? Perhaps we do. But there is evidence that kiwi females are not so "free" to produce new eggs if the goal is to maximize reproduction over a lifetime, not just increase the number of eggs laid in a single season. We weighed females shortly before and after their egg-laying time and found that they lost weight between production of the first and second eggs and were even lighter after laying a third. This suggests that in a pinch they are able to lay three or four eggs, but they cannot quickly compensate for the energy drain of producing even a single clutch of eggs. Since any further demands on her body may affect the female's health, probability of survival, and future fecundity, she may be better off with a single mate.

We concluded that the female's fidelity to her partner is at least partly dictated by energetic restrictions. This was supported by a comparison of the reproductive biology of kiwis in the various climate zones of New Zealand. On Stewart Island, in the cold and rainy far south of New Zealand, females of a different subspecies of brown kiwi were recently found to participate in incubation, and the same is true for the largest of the three kiwi species, the great spotted kiwi, or roa, which lives on the South Island. These birds are also monogamous, but females consistently lay clutches of only one egg. The harsh environment seems to compel these females not only to help their partners with incubation but also to reduce their clutch size to the absolute minimum. On the North Island, in contrast, the availability of food in the lush temperate to subtropical forests seems to enable males to meet the demands of incubating completely on their own. Yet the food supply may still be insufficient to allow females to lay clutch after clutch without wasting away under the rigors of egg production.

Why do kiwis lay these tremendous eggs in the first place? Why not lay plenty of smaller eggs? The answer has been sought in the kiwi's past. These birds probably descended from much larger ancestors, similar to the recently extinct moas. The remains of moas that were three times as tall and many times the mass of kiwis have been found with eggs only slightly bigger than those of present-day kiwis. Biologists Joel Cracraft, William Calder, and Stephen Jay Gould have proposed that kiwis have become smaller over evolutionary time, while their eggs have remained the same size for millions of years, as if the birds "forgot" to evolve egg size parallel to their body mass. Yet in many other birds, egg size has been shown to have been adjusted by natural selection.

This explanation also fails to account for the amount of yolk and for the extraordinary fat content of kiwi eggs. We believe that large hatchling size is the ultimate





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An adult attends a chick a few weeks old, below. For two or three days after hatching, chicks cannot stand up because the yolk sac inside their bodies is so big. Within a week, however, they can not only walk about but capture invertebrate prey on their own. Kiwis forage in an alpine grassland, right. These birds can be at home in habitats as varied as mountain tussocks, coastal dunes, and the Waitangi pine plantations.

Watercolor (below) and oil painting by Ray Harris-Ching



goal of laying these jumbo eggs. In some species, producing large chicks is important because tiny offspring may not be able to cope with sizable prey and may be unable to find enough small morsels to survive. They may also be easier quarry for some kinds of predators. For kiwis, however, these explanations fall short. Small soil organisms abound on the islands, and until recently no forest-dwelling predators endangered the ten- or eleven-ounce pullets. Because no indigenous predators have posed a threat to kiwis over thousands, perhaps millions, of years of island history, kiwis evolved no adaptations to cope with such dangers.

We propose a different explanation. Kiwis seem to be adapted so that their population density matches the carrying capacity of the environment. These adaptations include a low rate of dispersal, longevity, slow physical growth, and a low reproductive rate. Reports from the nineteenth century suggest that in some places kiwis were very numerous, even after European settlers began to change the face of the entire country. We believe that natural kiwi populations were dense and stable. Kiwis that produced the biggest, healthie chicks had an edge over their neighbor Big eggs, big yolks, and big chicks be came the reproductive ideal.

Unfortunately, the strategy that serve these slow, flightless ground dwellers s well in the past has contributed to their en dangerment in a modern New Zealan overrun with introduced predators. Today kiwis have disappeared from most parts o the country's two main islands, and wher they remain, they are under heavy pres sure. This is primarily due to only on predator species—the dog.

Kiwis are good sport for dogs; the have a strong odor and a loud call that car ries over long distances, and being flight less, they can escape only by rustlin through undergrowth, which makes them easy quarry. In addition, dogs can hunt th nocturnal birds largely unobserved. I 1987, an abandoned bitch killed an esti mated five hundred kiwis in less than two months, thereby eradicating about half o one of the world's last substantial kiw populations. We uncovered this massacr only by chance, when the dog also began to kill birds that we had equipped with transmitters for our study. Although thi discovery led to the dog's elimination when we returned to Waitangi in 1991, the remains of another twenty dog-killed kiwis were found near public paths. These birds had been unmarked and unsurveyed Since the chances of coming upon a kiw corpse are remote, this was certainly only the tip of the iceberg; the real number o losses must have been in the hundreds.

Fortunately, having learned from this second, sad demonstration of the devastat ing effect of feral dogs on kiwis, the au thorities in Northland have launched an ambitious program aimed at tackling the problem of irresponsible owners and stray dogs. The incredible number of unat tended dogs in New Zealand forests was recently demonstrated on one peninsula where kiwis once thrived. Seventy strays have been eliminated from there in the past eighteen months. Such intervention, along with education, can help insure that New Zealand's symbol survives. □




Scale
ALIEN
JANE

The Rise of the British Wedding Cake

The sun never sets on this vertical confection

by Simon R. Charsley

The towering sea cliffs of Colonsay, an island in the Scottish Inner Hebrides, front the Atlantic and protect wide bays of silver sands. White croft houses nestle around the bays. Behind cliffs and beaches, high hills of heather and bracken, which change color with the seasons, hide centuries of human presence, and wooded hills shelter farmland to the east. Only ten miles long and less than three miles wide, Colonsay in its variety is a Scotland in miniature.

The Big House, a handsome eighteenth-century mansion, is the home of the laird and his family, owners of almost all they

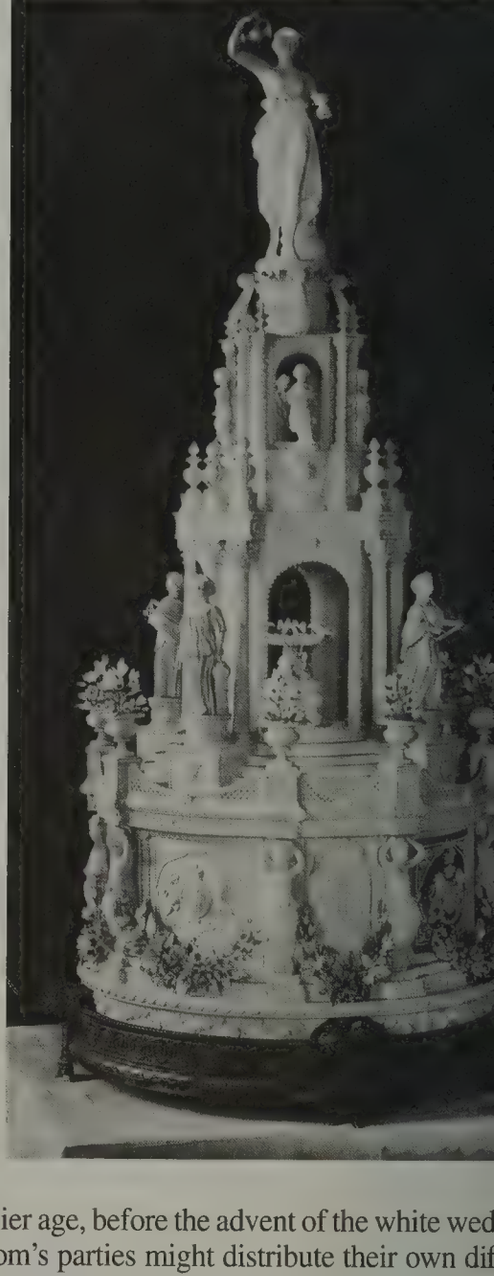


Created for the society wedding of a landowner, above, a contemporary cake—with its top layer fashioned into a map—represents the family's island domain in the Scottish Inner Hebrides.

Both photographs by James Fergusson



The art of Victorian confectionery may have reached its high-water mark with the wedding cake created for the 1871 wedding of Queen Victoria's daughter Princess Louise.
The Royal Archives, Her Majesty Queen Elizabeth II



survey. It is set amid lawns, eucalyptuses, and palms, with which its nineteenth-century residents marked their place at the center of "the empire on which the sun never set." The young laird was recently married here in an impressive society event. Family and friends, many from the south of England, poured in and joined islander guests. A sprightly man of seventy-five, who had worked for the family for the past sixty years, recalled that the wedding of the laird in the previous generation had been held in the south of England, five hundred miles away. In his opinion, this wedding in Scotland was far better, because there was music and dancing in the island tradition. A special cake, baked on the island, but sent to the mainland for professional icing, had been created in the shape of the island itself.

Scots believe that they know how to hold weddings. The program for such events, with its attendant enthusiasm, is rarely matched south of the border. For example, favors, ornamental knots of white ribbon—a tradition that had lapsed in England by the end of the nineteenth century—still have an important place in Scotland. In an earlier age, before the advent of the white wed ding, bride's and groom's parties might distribute their own dif ferent colors. Favors might be lightly tacked to the bride's dress and at a given signal, a scramble would take place as all presen tried to rip the favors off as personal trophies from the event Such robust customs—another was the breaking of an earlie form of "cake" over the bride's head—disappeared as prudish Victorian respectability took marriage celebrations in hand. In Scotland, favors somehow survived into the twentieth century not on the bride, but on the cake.

These favors were pretty confections of ribbon and artificia flowers, sometimes of tartan and heather, destined to be removed and distributed to the ladies—at first only to those particularly important to the bride, but by the 1980s to all the women present Since the cake could not hold favors for all the women, extra fa vors were brought along, and distributing them became a majo task that many a bride could do without. The custom insured that, in the course of the evening, she would get around to all he

nale guests and that bride and groom would be kept mostly art. The Scottish cake, therefore, made a contribution to the oceedings that the English cake did not.

But the wedding cake was, at its roots, primarily an English eation. In wealthy, aristocratic circles in the seventeenth cen-y, there developed what would still be a recognizable dark itcake. The starting point had been loaves of bread baked for lebrations. Over the years, these were enriched with "plumbs" ied fruits), eggs, sugar, nuts, spices, and alcohol. Special and stly, such a cake might be served to guests at grand wedding lebrations, but it was only with the addition of a distinctive neme of sugar icing that something identifiable as a wedding ke was achieved.

The creation from sugar of a smooth, icelike white topping s discovered and developed at much the same time as the itcake, but it was used for small, highly valued confections, mond marzipan in particular. Only the best and most costly gar available would give the whiteness desired, but the use of at to set the "ice" risked spoiling even the whitest surface. To ply icing successfully to the large surface of a cake was alto-ther more ambitious, a great and costly endeavor. By the eight-nth century, after improvements in refining and much experi-enting, large, plain, white-iced fruitcakes were available for ry special occasions.

The credit for the next step, arriving at something that could called a wedding cake, belongs to Elizabeth Raffald, an enter-ising eighteenth-century woman who had retired from a career housekeeper in a succession of grand households. In 1769, she ened a confectionery shop in Manchester and published one the great eighteenth-century cookbooks, *The Experienced nglish Housekeeper,* which gave a distinctive recipe for a wed-ng cake. The mixture more or less followed established prac-e in terms of ingredients and measurements, but the icing was mething new. Mrs. Raffald recommended an icing composed ground almonds as well as sugar. Yellowish in color, it was en covered over with a second icing, the usual pure white layer. he almond icing had the practical advantage of insulating this ter surface from discoloration by the juices and oils in the cake elf, but its chief attraction was probably just that it was some-ing different, appropriate, and enriching.

A cookbook published by a London chef the following year mediately took up the same recipe. Although he very properly tributed it to Raffald, she was clearly not pleased to have it ized upon by others. Whatever happened between them, when published a second edition of the book two years later, Raf-ld's icing recipe had disappeared. No one else tried to publish until well after her death in 1781, and her own book continued legitimate and pirated editions for well over fifty years. Her uble icing worked its way into the English understanding of e wedding cake.

Color and decoration in icings came next, when whiteness was longer a difficult attainment. In Scotland, the confectioners of

In "Twelfth-Night Cake for Kings and Emperors," an 1898 French lithograph, Queen Victoria, Kaiser Wilhelm II, Czar Nicholas II, and Emperor Mutsuhito prepare to divide China, as China protests and France looks on.
The Granger Collection



Edinburgh turned to pink icings on wedding cakes. Bride's pies of spiced meat and fruit were another of their products, and both pies and cakes were decorated with leaves and flowers and such vigorous motifs as flames of passion and cupids with their darts of love. England had no such lively wedding dishes, but it did have a large, iced, and colorfully decorated Twelfth cake, which celebrated the end of Christmas on Twelfth Night, January 6. In contrast, the English wedding cake was serious. It tended to avoid the new and frivolous and stuck longer to the decent plainness of the past. It was ready, then, to take its place within the great white wedding, as the Victorian preoccupation with purity was established.

Plainness was not, however, a Victorian value, and it was not to survive the succession of massively publicized weddings of Queen Victoria's daughters in the late 1850s. New standards for elaborate decoration were set, but warmth and passion were not to be acknowledged in the decorous formality of the new wedding. This tone spread to Scotland: cakes there had to turn white

The Twelfth Cake

by Bridget Ann Henisch

Epiphany, the feast that commemorates the coming of the Three Kings to Bethlehem, has long been honored in Europe, not only with religious services but also with exuberant fun and feasting. In England, the day—January 6—used to close the great holiday season known as the Twelve Days of Christmas, and the feasting and games required a special cake.

Throughout Europe, traditional games center on choosing a "king" for the night, but the rules vary from place to place. In France, the lucky winner is the one who finds a bean hidden in the cake. The game was played in this way in England, too, until late in the seventeenth century, when another method was devised. The king was chosen by lottery, as everybody present drew a marked slip of paper from a bowl. With these new rules, there was no temptation to tear the cake to pieces in a mad treasure hunt. Instead, it could be enjoyed in comfort and appreciated for its own considerable charms. This variation made its way to America, and many accounts of Twelfth Night parties are recorded in eighteenth-century Virginia. There, guests were happy to choose kings and consume cake in the fashionable English way, whatever their private opinions of George III.

The eighteenth century saw the development of the characteristic English celebration cake, still produced today for special occasions. The period was robust, and so was the cake. Nothing was ethereal about it. Large and substantial, dense and dark, it was packed with sugar and spice, raisins, currants, and candied peel and held together with modest amounts of flour, heroic quantities of eggs, and strengthening spoonfuls of alcohol. Sometimes, for extra nourishment, it was topped with a generous layer of almond paste. This was the basic cake, which for noteworthy occasions, whether Christmas or christenings, weddings or wakes, could be glamorized, sheathed in the magic of smooth, white icing.

The Twelfth cake, served on January 6, was of this kind. What made it special was the decoration. A snow-drift of icing cried out for ornament, and cooks rose to the challenge. Crowns and kings, clowns and fairies, favorite characters in age-old stories, and up-to-the-minute celebrities were modeled in sugar paste or plaster, colored, gilded, and set out on the shining surface of the cake.

Enthusiasm for the fashion reached its peak in the first half of the nineteenth century. At that time, in the Christmas season, the windows of confectioners' shops sparkled with eye-catching displays, and to stroll from one to the next and choose the winner was a favorite pastime. The special cakes created for Queen Victoria by her yeoman-confectioner received full coverage in the newspapers.



A double-iced Twelfth cake
Alan Newnham; CP/Globe Photos

After this blaze of glory, the fashion died down. From midcentury onward, social and economic forces insured that Christmas Day itself absorbed all the attention. The old twelve-day festival no longer fitted into a business year shaped by notions of productivity and profit. The span of the season contracted, while new customs, like the sending of Christmas cards, laid even more emphasis on December 25. By the end of the century, Twelfth Night ceremonies had become faint memories,

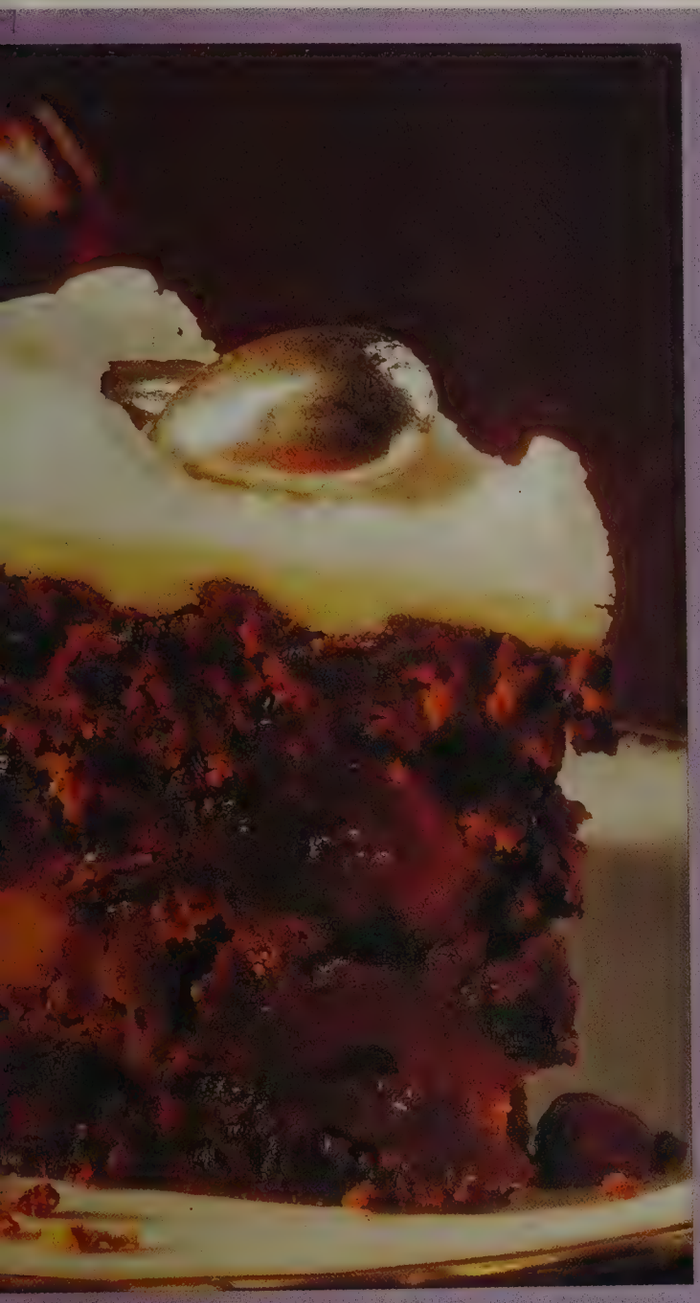
and reform their indelicate symbolism. They fell into line with the English cake.

Up to this point, wedding cakes had been large, as befitted important occasions, but otherwise simple—usually round and flat. The Victorian aesthetic, however, was for the vertical. To be impressive, dishes should rise and stand tall. Ordinary, smaller cakes were being baked in deep molds to achieve the effect, but the wedding cake was already too large for such a solution to be practical. When expense was no object, as at the queen's family weddings, the answer was to build a vast sugar superstructure of pillars, arches, and towers, rising above the cake itself at the base, but this required expense and artistry far beyond middle-class means and confectioners' skills.

The first practical solution was to raise the big cake on a stand and place a vase of flowers on its top, the whole confection then becoming impressively tall. Later, another more interesting possibility was discovered. More height could be achieved with a pile of cakes of successively smaller diameter, placed one on top of another. There could still be a stand and flowers on the top.

By about 1880, a wedding cake consisted of three such "tiers," unified with a rich profusion of ornamentation from top to bottom. This was the ideal, but most cakes actually made during the next half century usually had only one tier. The cost of three full tiers put them beyond most people's reach, but the model in the shop window asserted the standard and put pressure on those who could afford it to go one tier higher.

Ornamentation also became a key element, thanks to an earlier invention by a French patissier in Bordeaux, a Monsieur



t the cake was too good to be allowed to vanish. By a deft change name, it escaped extinction and survives today as the much-loved ristmas cake.

idget Ann Henisch's books include Fast and Feast *(Penn State ess, 1976) and* Cakes and Characters *(Prospect Books, London, 84). She is coauthor, with her husband, of* The Photographic Ex- rience, 1839–1914; Images and Attitudes, *which will be pub- hed by Penn State Press in the spring of 1994.*

orsa. He had observed an apprentice cut the end off a paper oke in which sweets were sold in the shop, fill it with a eringue mixture, and with it write his name on the workbench. Vhen Lorsa instead filled the poke with the royal icing that he sed to decorate marzipan, "piping" was born.

Piping reached England by the late 1880s and flourished ex- eedingly. It was promoted mainly by confectioners from the ontinent, who exhibited their marvels and won prizes at exhibi- ons. The style of decoration was perfectly in tune with the Vic- orian ambience—decorative elaboration and abstract formality, afely removed from human emotion or meaning of any kind. Vhus, with double icing, piping, and tiers, confectioners per- uaded the populace at large that this was indeed the only really ermissible style for a proper wedding cake.

This Victorian cake, achieved in the very last years of the queen's reign, was not to be the end of the story. At the beginning of the twentieth century, after some experimentation to gain yet more height (one idea was pushing the trunk of a small tree through a tier to suspend it in midair), each successive tier was lifted on pillars and decorated, echoing the others on appropriately different scales. The tall pillars gave an effect of lightness as well as of height, and the restrained, repeated decoration introduced a new elegance. Now that the cake itself had achieved its own great height, the vase of flowers on top—formerly lavish—was reduced to a small token. This was the Edwardian cake, the cake that has lived on in English and Scottish consciousness through most of the twentieth century. It would participate in the big day of innumerable brides and would travel the world, undergoing, as in India and Japan, some remarkable transformations and accommodations on the way.

What accounts for the persistent popularity of the wedding cake, an extraordinary object that has taken shape so intricately over a period of three centuries and slipped its local moorings to range the world? While the cake unequivocally proclaimed "wedding," it avoided saying anything more about what was going on. Its symbolic blankness had its own particular importance in the long aftermath of Victorian sexual prudery. Like the voluminous white dress and veil that disguised the bride's body, a petrified, decorous, and impersonally magnificent cake diverted attention from the nature of the personal relationship that the wedding was authorizing.

The cake was also important for its part in the wedding proceedings. In Scotland it was, first of all, the vehicle for the favors. Oddly, the actual eating of the cake never had any significance. Guests would be served a small piece at the reception following the marriage ceremony, but nothing turned on whether or not it was eaten. Pieces might in fact be taken home and, as is still sometimes done, put under the pillow at night for girls to dream of their own future husbands.

What was essential was the ritualized cutting of the cake. This had its point of departure again in the Victorian middle classes, when the new wife would exercise her first hostess role by cutting cake for the guests. With the Edwardian cake, however, the icing was hard and strong, so that the wife's task became a challenge to be undertaken with the help of the groom. By the 1930s, the joint cutting of the cake was the high point of every wedding.

Two other uses of the cake were important, too. Pieces were needed for subsequent distribution to others who had been unable to attend, and the top tier was to be "kept for the christening." This latter idea was commercially motivated, but it was soon taken into the popular repertoire and passed on as folk wisdom to succeeding generations, even to the present day. The cake, an object of carefully restricted meaning but [illegible] important uses, was therefore firmly established in wedding tradition.

By now, the bride and cake are closely associated in the popular mind. Once, in the midst of my research on marriage in Glas-



Hailed by fellow woodcraft enthusiasts at a 1928 British wedding, the bride and groom prepare to cut their cake with an axe. Below: A jockey and his bride at their 1930 wedding reception in London's Mayfair district. The vase of flowers that added height to Victorian cakes persisted as a tradition and topped the multitiered cakes of later times.

Both photographs from the Hulton-Deutsch Collection





gow, which had set off my interest in these matters, I was dozing in a warm train as I traveled to give a talk on my findings. Into my half-asleep mind suddenly slipped a transforming image of cake and bride as one and the same. The white-dressed bride, tapering upward from her wide skirt to her veiled head, merged with the white cake tapering from its broad base to the decoration on its top. Instantly fully awake, I was aware that a new dimension had entered my thinking. I remembered the favors once on the bride's dress and now on the cake. I remembered, too, that cutting the cake involved plunging a knife into its center. Oddly enough, on returning home, I found that my assistant on the project had interviewed a prospective bridegroom who, with his fiancée, had decided against a cake, because he felt its cutting symbolized the bride losing her virginity. As a modern couple

Haga Lib

Elaborate wedding cakes have become popular throughout the former British Empire and beyond. Below: At a Lagos, Nigeria, wedding, guests seated at the dais gaze upon a cake that depicts the joining of two prominent families. Right: New heights are achieved in Hokkaido, Japan.
Juliet Highet; Hutchison Library



with feminist inclinations, they could not tolerate such sexist notions: they would do without a cake altogether.

Since these coincidental experiences about ten years ago, cakes have remained as popular as ever, but the old standard form, so slow in evolving, has suddenly been undermined by a host of alternatives—styles from the past and from other countries. In particular, a flexible, sugar-paste icing has been introduced. Pioneered in Australia, this offers an easy medium for fine and naturalistic modeling and encourages a representational style of decoration that reverses the priorities of the old. Cakes can now be personalized in ways that the old style pointedly rejected. The most eccentric cake I have yet to come across was in the form of an old boot, which apparently played a significant part in bringing one couple together. The most charming was a cake surmounted by a sugar settee, the bride and groom seated on it surrounded by children from previous marriages.

Why this sudden change? This century has seen the slow undermining in Britain of traditional values and forms in marriage. Radically new and more individualistic understandings of th rite have set in. Meanwhile, cake decorating has become a pop ular art form, with a widening range of occasions providing ex cuses for the creation of innovative cakes. This wave of enthus asm has broken through to the wedding cake. The ol gatekeepers, the professional baker-confectioners, have lost con trol of the product, and couples are now able to match their cak with their conception of the event to be celebrated.

So what of the young laird of Colonsay? His cake was his is land. Today, does he still have the power through ownership t control the lives of the islanders and the island's future? Wha would be the symbolism of plunging a knife into the heart of tha cake? Perhaps we should believe, for the moment, in the ol ways and not delve too deeply into symbolic meanings. An what of Scottish favors on the new, sugar-paste style? Will the disappear, denied their place like so much else Scottish in th face of standardizing pressure from England? Or can we hop for their return to the person of the bride? □





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For valid reason, **Costa Rica** is called "Nature's Museum...." Five percent of all plant and animal species that exist in the world, exist in Costa Rica. Some twenty-five percent of the entire country (19,653 square miles) is protected under its own government ministry. Several of the forty-one national parks have been declared Biosphere Reservations and part of World Heritage by UNESCO.

There are twelve sharply differentiated ecological systems throughout seven provinces that span tropical rain forests and a unique 4,000-acre Monteverde cloud forest; jungles that are home to 845 species of birds, 208 species of mammals, 160 amphibians, 220 types of reptiles and over one thousand varieties of fresh and salt water fish. Sun-bleached beaches spread out along two oceans, the Atlantic and the Pacific. Atop mountain peaks in one of the most dramatic national parks, Chirripo, hikers can view both oceans.

At Poas National Park (the most visited in the country), five volcanic craters tower to 8,884-feet, and visitors can actually walk along the dormant rims.

Recently, the Costa Rican Institute of Tourism created a "Gold Pass" that has no expiration date and provides savings on park entrance fees. For more travel information on Costa Rica, contact Wildland Adventures at 1-800-345-4453.

St. John, the smallest of the **U.S. Virg Islands,** is only twenty-eight square miles area, but more than three-fourths of t tropical island is under the protection the Virgin Islands National Park. This a includes the off-shore waters.

It's possible to stay at an upscale priva campground on St. John (Maho B Camps) in tent cottages made of canv nestled into ecologically-desirable tropic green, all with beach views. Guests recei linen and towels, beds, electric lamps and propane stove. True campers can opt to serve basic tents or just bare sites at the Ci namon Bay campgrounds, operated by t U.S. National Park Service in St. John.

The little island of **Barbados** possesses n only great natural beauty but a wealth of a chitectural styles—from charming chatt houses to stately plantation manors—ov 350 years of architectural treasures.

The National Trust was founded in 196 to preserve the unique heritage and natur environment of Barbados. The Tru works to ensure that the public has acce to as many properties as possible.

The Trust maintains numerous properti that are open daily for visiting: Tyrol Co (historic 1854 mansion), Welchman Ha Gully (jungle walk), Morgan Lewis Suga Mill, Sir Frank Hutson Sugar Machiner Museum, Andromeda Botanic Garden Gun Hill Signal Station, St. Nicholas Abbe and the Sunbury Plantation House.



Birdwatching, Tortuguero National Park, Costa Rica



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A vibrantly colored iguana, West Indies

The **Bonaire** government (in cooperation with the World Wildlife Fund) has created the Bonaire Marine Park, which includes the entire coastline to depths of 200 feet. Visitors are more than welcome to swim, snorkel, or scuba, but not to take.

Above water, the unusual 13,500-acre Washington/Slagbaai National Park is a wilderness sanctuary of tropical desert terrain with marked trails and 130 species of birds. It was one of the first national parks established in the Caribbean.

PARLEZ-VOUS PARROT?

The **Cayman Island** triplets—**Grand Cayman, Cayman Brac** and **Little Cayman**—are well-known havens for scuba divers and snorkelers. Lesser known is that each island has its own protected area where you can actually see ecotourism in action.

The captive breeding program for the (almost extinct) Grand Cayman blue iguana began with two "gift" iguanas. Presently, there are over thirty blue iguanas on the site, and as of November 1993, the captive breeding site will be part of the nature trail in the new Cayman Islands Botanic Park. The one-mile trail will also be marked with flora and fauna identification.

When one hundred acres were set aside in 1991 as a Nature Reserve in Cayman Brac for the endangered Cayman Brac parrot, it was a gift with "double" meaning. By happenstance, the acres donated were in the heart of the parrot's traditional nesting area. Today, some 400 birds of Amazona luecocephala hesterna, a sub-species found only in Cayman Brac, are thriving.

All of Little Cayman Island is a "birder's" paradise, with blue herons,

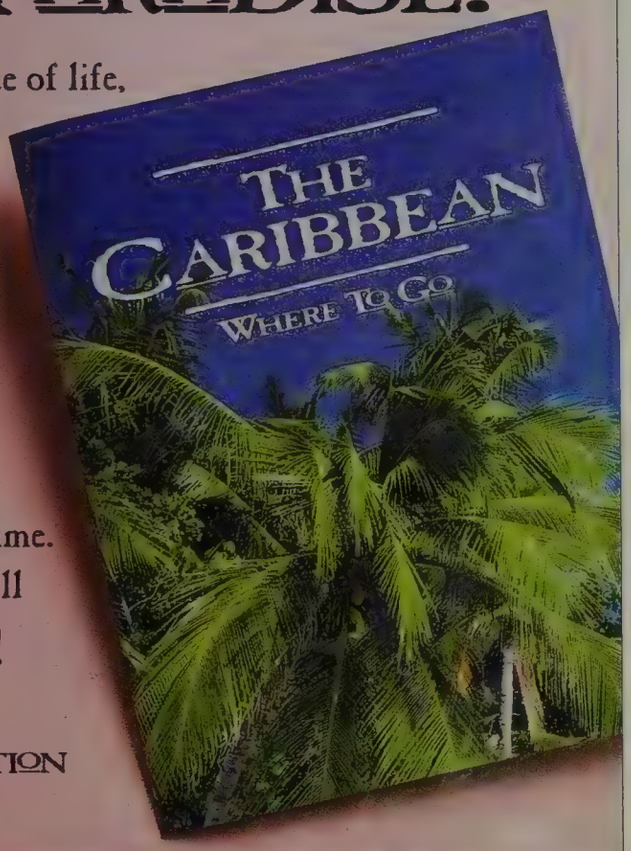
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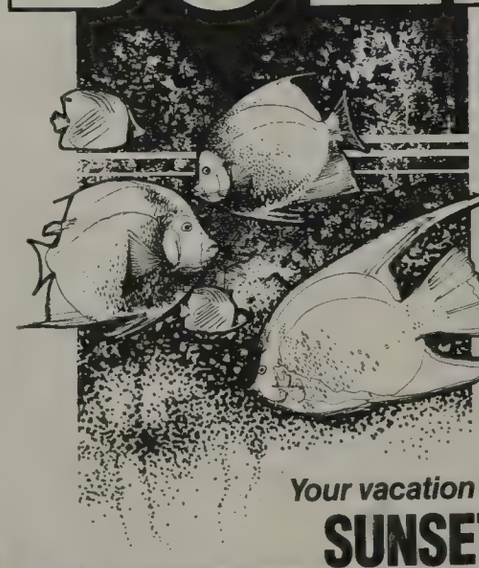
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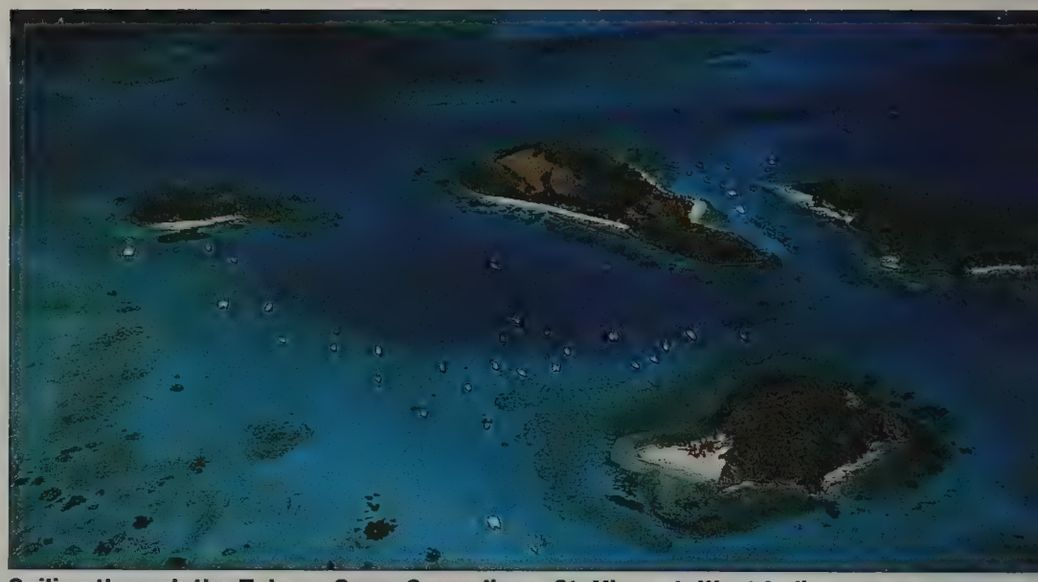


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frigates, the unusual West Indian whistling duck and the only breeding colony in the Caribbean for red-footed boobies (thought to number around 4,000).

The country of **Belize** so values its natural gifts that they have been declared "National Treasures." Belize is already well known as a world-class diving spot (it has the world's second-largest, unbroken, living coral reef), but its wildlife preserves are lesser known.

It's about a forty-five-minute drive from Belize City to the Community Baboon Sanctuary at Bermudian Landing. This is an eighteen-square-mile sanctuary that took the cooperation of local farmers to make it a "safe haven" for the endangered troops of black howler monkeys that travel in groups of eight in the treetops. In order to ensure their safety, local farmers have signed pledges to "work their farms" in cooperation with the food needs of the black howler monkey. There are seven Creole villages in the sanctuary that offer visitors an intimate day of rural—and real—Belize life, in addition to the awe-inspiring sight of the baboons themselves. Their rasping howl can be heard well over a mile, so visitors are never disappointed!

In **Curacao,** interest has been so high in the indigenous white tail Curacao deer, present on the island since pre-Columbian times, that actual "deer watching" sessions are held year round from 4 to 6:30 P.M. at the 4,500-acre Christoffel National Park. It is estimated that there are some 150 to 200 deer remaining. Reservations are required, and a maximum of eight guests are taken by guide



Black Howler Monkey, Belize

to the water reservoir where the deer tradi tionally drink at day's end (tel. 640363).

Two of **Puerto Rico**'s many offshore is lands are major drawing cards for natural ists. Seven-mile-long Culebra Island ha dedicated four tracts of land and twenty three offshore islands as wildlife refuges From May to September, the sooty tern hold court. And from mid-April through early July, the world's largest turtle, the giant leather-back (weighing some 1,200 pounds and up to six feet long), returns an nually to lay billiard-shaped eggs on the Playas Brava and Resaca beaches.

A trip to Mona Island, another of Puerto Rico's offshore islands, is only for the de termined. Here, cliffs up to 200 feet high surround the island, and are honeycombed with complex cave systems. Once home to Taino Indians, farmers and pirates, Mona Island is now inhabited by yard-long igua nas, boobies and other seabirds.

For people willing to put some "work" time into their naturalist tendencies, Earthwatch has two ongoing programs in **St. Croix.** Project volunteers pay to participate in saving the leatherback turtle. From April through July, night patrols are needed at Sandy Point, a St. Croix National Wildlife Refuge. Beach-walking crews will record data from nesting mothers, measure nest temperatures, move erosion-prone nests and escort hatchlings to the sea (tel. 800-776-0188).

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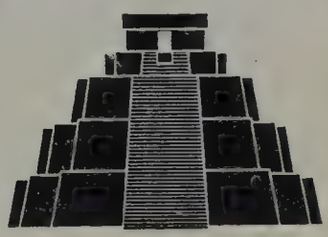
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Jumby Bay is an elegantly casual, private island, a fifteen-minute launch ride from **Antigua's** northeast shores. The centerpiece for this very well-stocked resort is a 200 year old Spanish estate, where international guests from thirty-eight cottage suites or fifteen private villas gather in the evenings. In addition to four-and-a-half miles of walking or bicycling paths and three night-lit tennis courts, dollops of scattered beach host private picnics, snorkeling or sea-cycling. From July to December, there's a serious ecological side to life at Jumby Bay. That's when the "turtle ladies," zoologists Simeña Prudencio and Heather Mayers, oversee a program to expand the diminishing number of Hawksbill turtles. Jumby Bay appears to have the most dense Hawksbill population in the Caribbean. For centuries, female turtles have laid their eggs on Pasture Bay Beach. Guests are led by flashlight under the hushed instruction of the "turtle ladies" for nocturnal sightings.

Guana Island, in the **British Virgin Islands,** says it best: "we're the only wildlife sanctuary with a cocktail hour." The entire 850-acre island is an officially designated wildlife sanctuary. It has more flora and fauna than any other geographically-similar site in the world. In July and October, scientists share the six cottage accommodations or expansive villas (guest complement is only thirty) in an ongoing study of this naturally preserved find. Owners Henry and Gloria Jaracki have reintroduced the endangered Anagada rock iguana and replenished the dwindling flock of Caribbean roseate flamingoes. People however, are not forgotten. They can trace time on mile-long White Bay Beach, or wander to six other scoops of vanilla cream sand and have a private picnic. Other options include tennis, snorkeling, beach walks, or muscle-firming hikes on hilly nature trails past sugar mill ruins on 806-foot-high Sugar Loaf Mountain. When the Jarecki family purchased the island in 1974, their intent was to preserve the past with discreet pruning and pampering. Candlelight dinners on a terrace that overlooks both the Atlantic and the Caribbean inevitably turn into an international house party.

—Sandra Hart

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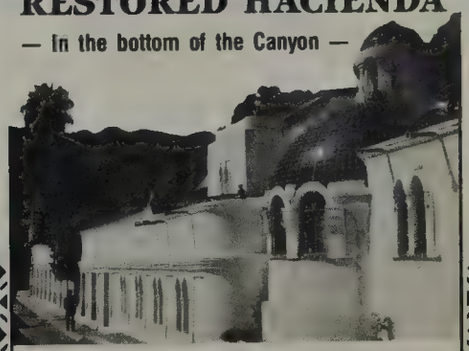
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At Home in Nature

by Joseph Kastner

A few months ago in this magazine, Stephen Jay Gould wrote an essay on "The Invisible Woman," the women naturalists who, oppressed "by a sexist sociology of disciplines," were excluded by the male hierarchy from serious recognition in natural history.

Now, in *Made From This Earth,* Vera Norwood takes up this theme in a wide-ranging and ambitious book that, in many ways, makes up for the not-so-benign neglect that natural historians—almost entirely male—have visited on women naturalists. Norwood's subtitle, *American Women and Nature,* explains her large purpose: not only to give women naturalists their deserved place in the history of natural history but also to explain the special relationships women have with nature. This makes for a diverse and sometimes unexpected cast of characters—naturalists, hunters, illustrators, novelists, gardeners, science fiction writers, and metaphysicians. Dense with fact and discursive in approach, *Made From This Earth* succeeds best by giving an understanding of how both the study of nature and the attitudes toward it are governed by gender.

Women in natural history, says Norwood, appear "as significant actors only sporadically, and then in roles meshing perfectly with gender stereotypes." Although forced to play supporting roles, women still developed a distinct and separate tradition, which was, to use Norwood's own simplification, to make the environment "one's familiar and home."

Her women appear, again and again, as teachers. Almira Phelps, sister of the schoolmistress Emma Willard, wrote *Familiar Lessons on Botany* (1829), which sold an astonishing 250,000 copies and led to the establishment of nature study centers all over the country. Emphasizing the "morals taught in nature," Phelps educated women to educate other women in botany, making that discipline the preeminent popular science of the nineteenth century (see "The Innocent Science," *Natural History,* October 1992). For all her own success, Phelps seemed to accept women's secondary role. Females, she stated, "are not expected to enter into the recesses of the temple of science; it is of but late that they have been encouraged to approach even its portals and to venture a glance at the mysteries within." If there is any irony



Writer and explorer Mary Hastings Bradley, with her daughter Alice, on the American Museum of Natural History's 1909 collecting expedition in Uganda.
AMNH

at statement, it is what we put in it today. Decades later, Anna Botsford Comock at Cornell emulated Phelps with her *andbook of Nature Study* (1911), which ecame a bible of the American classom. The most widely influential memr of Cornell's faculty, she never made it y higher than assistant professor.

Norwood keeps emphasizing that



women brought a domestic viewpoint to the appreciation of nature. Susan Cooper, the daughter of the famous novelist James Fenimore Cooper, was a "literary domestic," whose volume of essays, *Rural Hours* (1850), matched in popularity those of Emerson, Thoreau, and Burroughs. Cooper's method was modest, describing the changing seasons as she saw them around her home in upstate New York. Setting out, as Norwood puts it, to bring "the scenes and values of middle class homes to a wide readership," Cooper wrote of parent birds scolding their fledglings for misbehaving and chattering about family matters to one another. Although her eye was on the household, she set a wider role for women as special protectors of nature, just as they were of the home. Well ahead of her time, she declared that it was as much a responsibility to preserve an old forest as to save an ancient monument. Cooper provides Norwood with a grand generality: because of her, the conservation of nature became a significant function of gender.

Tracing traditions, Norwood finds a lineal descendant of Cooper in Mary Treat. Although more knowing about science than Cooper, she still looked on nature as a household. In *Home Studies in Nature* (1881), spider mothers give homilies on manners to their children, and young spiders shedding their skin are getting rid of "baby dresses." Treat was one of an extraordinary group of nature writers—Olive Thorne Miller, Florence Merriam, and others—whose best-selling books taught

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MADE FROM THIS EARTH: AMERICAN WOMEN AND NATURE, by Vera Norwood. *The University of North Carolina Press, $37.50 ($17.95 paper); 368 pp., illus.*



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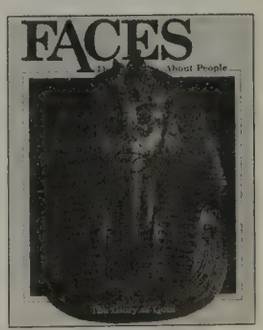
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generations of children about nature and the need to protect it.

Women illustrators were the handmaidens of natural history, bound to the male scientists whose work they amplified with precise and elegant drawings. Lucy Say in the 1830s did the illustrations for her husband Thomas's pioneering *American Conchology* and then hand colored the engravings made from them. When she finally was allowed to do engravings herself, she was criticized for taking on man's work. As she told it: "A gentleman remarks 'Well, at what do you think the ladies will stop?' I replyed I hope at nothing short of breaking the Monopoly so long held by the Gentlemen—that we were tired of cramping our genius over the needle and distaff."

Say's rebellion got her nowhere, but her achievements set precedents. Early in this century, the U.S. Department of Agriculture became a haven for women illustrators who did the drawings for the department's countless pamphlets and guides. A talented, hard-working group, they made a niche for themselves in a man's world by giving up everything else, settling for what Norwood calls a life of "celibate careerism." Only one of them, Agnes Chase, became known in her own right. After having spent twenty years illustrating A. S. Hitchcock's monumental treatise on grasses, she took charge of the whole project when he died—in part because there was no male who could fill the post so well and in part, maybe, because she was feistier than her demure sisters in art. A militant suffragette, Chase demonstrated repeatedly for women's right to vote and went to jail for it twice.

The emergence of women from their subservient roles came with Rachel Carson, whose work broke the gender issue wide open. *Silent Spring*, the most significant environmental book of the century, was either smugly patronized or attacked by the male establishment as "hysterically overemphatic." For a man, Norwood says sardonically, "reading *Silent Spring* was akin to having an argument with the wife—and about as important in the affairs of the world." The male reaction roused a huge network of women's organizations to defend Carson and demand equal respect for women—and to succeed in both. For all her revolutionary impact, Norwood argues, Carson was still carrying on woman's traditional domestic work as the preserver of nature.

In the post-Carson era, the ecofeminist movement seeks to merge natural history and feminism, to identify "disturbing connections between the domination of women and the domination of nature." Norwood points out that this sometimes involves "a somewhat mystic metaphysical interpretation of quantum physics" offering "a model of human-nature relations as a constantly changing field of possibilities." The ecofeminists are a thorny group, and Norwood, openminded but questioning, is good at explaining their common purpose: to inject "ecological goals into the woman's movement."



A scientific collector who learned taxidermy as a college student in the 1860s, Martha Maxwell took up the gun to collect her own specimens.
Colorado Historical Society

To explore the ways women's own natures reflect nature at large, Norwood turns to women novelists—Zora Neale Hurston, Toni Morrison, and Ursula LeGuin among them. Their voices are too different, their expressions too subtle or too passionate to be lightly summarized. Eloquently and sometimes subliminally, they reinforce a passage by Susan Griffin that gives the book its title: "I am made from this earth...all that I know speaks to me through this earth...*we speak to each other of what we know: the light is in us.*"

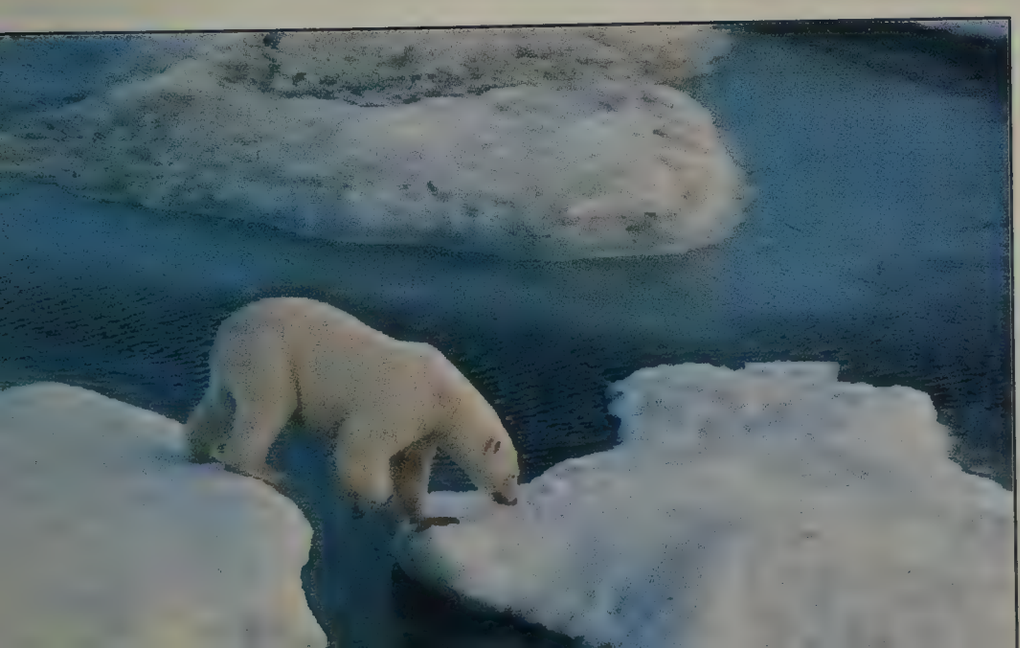
Although she gives men the back of her hand from time to time, Norwood does not waste time bashing them. She is concerned more with what women have done than with what men did to them. But she studs her books with laid-back feminist

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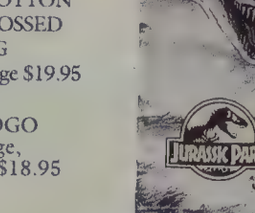


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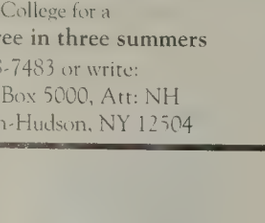
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comments. She says that women big-gar hunters, who could be as good as men bagging prize specimens, used the gun f objective purposes: "The gun held rathe different meaning for them.... The trop did not signify a step in the charmed circ of adulthood. These women were alrea adults, going about...[the] business...[educating] the public about nature."

For the most part, women did not co plain too much about being kept in th place. But some turn-of-the-century wr ers did. Florence Merriam, whose ornith logical books made her the peer of a man in the field, anticipated today's fem nist attacks on male nomenclature by r gretting that birds have to "bear their hu band's names...however inappropriat An innocent creature with an olive ba and yellowish breast has to go about all h days known as the blackthroated warbl just because that happens to describe t dress of her spouse." And Mary Austin *The Land of Little Rain* staked out an e sential female claim on nature: "If t desert were a woman," she wrote "s would be deep breasted, broad in t hips...eyes sane and steady as the polishe jewel of the skies...passionate, patient- and you could not move her, not if you ha all the earth to give."

Norwood has covered enormou ground—her bibliography takes twenty five pages to list references and source She does not set out to be encyclopedi however, and her omissions are too obv ous to be put down to oversight—ba mention of women herbalists, for ex ample, and none at all of Margaret Mor Nice, who, through her classic study of t song sparrow, fits Norwood's domestic d finitions to a tee. In places, her proposa are more suggestive than convincing, an you come away with more perception than proofs. But that just means a litt more work for the reader, which in view o all the work Norwood has done, is fa enough.

Made From This Earth deliberately by passes male work in natural history, usin it simply as a backdrop for women's work This is in no way distortion. Rather, it i refraction, history bent to give a truer illu mination of American natural history— providing a wholeness that sexism has, fo so long, denied the discipline.

Joseph Kastner, whose biography of Joh James Audubon for young readers wa published last year, has written on the his tory of natural history in A Species o Eternity *and* A World of Watchers.

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The Winter Revels

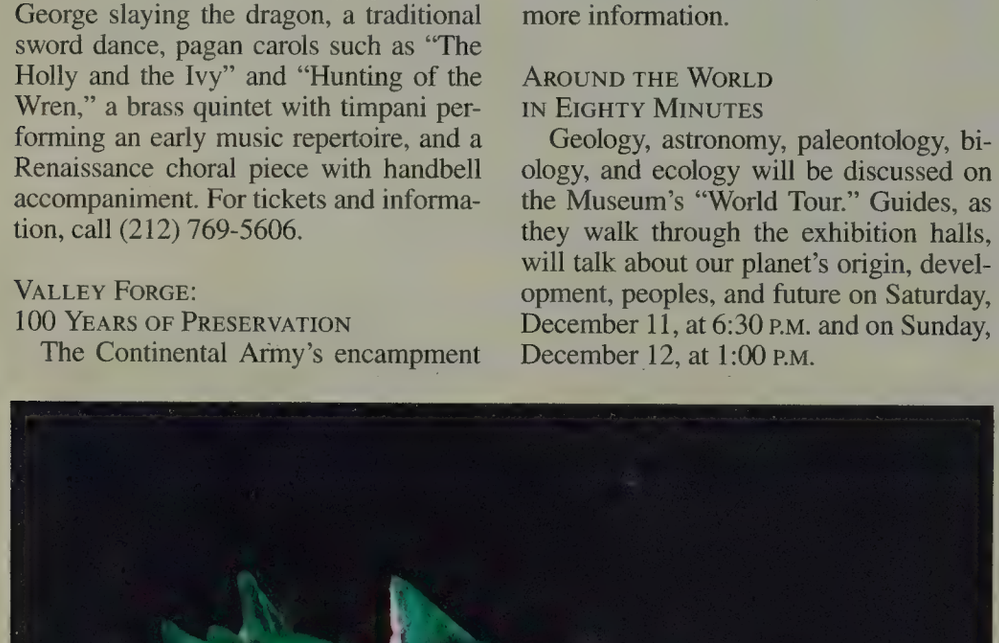
The New York Revels—a group dedicated to teaching traditions relating to the winter solstice—celebrates this ancient holiday with rituals and pageantry in the Museum's Main Auditorium for four evenings, from Monday, December 6, through Thursday, December 9. The festivities will include the folk play of Saint George slaying the dragon, a traditional sword dance, pagan carols such as "The Holly and the Ivy" and "Hunting of the Wren," a brass quintet with timpani performing an early music repertoire, and a Renaissance choral piece with handbell accompaniment. For tickets and information, call (212) 769-5606.

Valley Forge: 100 Years of Preservation

The Continental Army's encampment at Valley Forge during the harsh winter of 1777–1778 marked a turning point in the Revolutionary War. In 1893, the site was recognized as a national historical park. This centennial year, park superintendent Warren D. Beach will talk about the legacy of Valley Forge on Wednesday, December 15, at 7:00 P.M. in the Kaufmann Theater. Call (212) 769-5606 for more information.

Around the World in Eighty Minutes

Geology, astronomy, paleontology, biology, and ecology will be discussed on the Museum's "World Tour." Guides, as they walk through the exhibition halls, will talk about our planet's origin, development, peoples, and future on Saturday, December 11, at 6:30 P.M. and on Sunday, December 12, at 1:00 P.M.



The dragon battles Saint George in the New York Revels' performance of a medieval mummers' play.
Sam Sweezy

The Museum's annual holiday history tour in sign language, on Saturday, December 18, at 1:45 P.M., traces the origins of New Year celebrations around the world. Although the tour is free with Museum admission, call the Volunteer Office at (212) 769-5566 to reserve spaces.

Holiday Events at the Planetarium

At their tenth annual concert, "Under the Stars," the New York Philomusica will perform a selection of orchestral music from the baroque period to the present. The concert will take place in the Sky Theater, which will be embellished with laser lights and other special effects, on Wednesday and Thursday, December 15 and 16 at 7:30 P.M. Tickets are $18 ($15 for members).

The Planetarium's holiday story, "Star of Christmas," showing the skies the Wise Men saw when they were traveling to Bethlehem nearly 2,000 years ago, will alternate with "Orion Rendezvous: A Star Trek Voyage of Discovery." For information about these sky shows and all Planetarium events, including the Star Trek exhibition, call (212) 769-5900.

Global Cultures in a Changing World

As part of the Museum's year-long celebration of cultures in a changing world, the education department will present free lectures and performances. This month's programs will include the indigenous and mestizo music and dance of the Andes presented by the group *Inkhay* on Wednesday, December 1; the film *Five Centuries Later,* which examines the current status of Central American aboriginal civilizations, on Tuesday, December 7; and programs each Saturday and Sunday in the Leonhardt People Center during the first two weekends in December. For a complete program schedule, call (212) 769-5315.

These events take place at the American Museum of Natural History, Central Park West at 79th Street in New York City. The Kaufmann Theater and the Leonhardt People Center are located in the Charles A. Dana Education Wing. The Museum has a pay-what-you-wish admission policy. For more information about the Museum, call (212) 769-5100.

In Celebration of the 125th Anniversary of the American Museum of Natural History





AROUND THE WORLD EXPEDITION

By Private Jet
January 19 - February 21, 1995



For nearly 125 years, the American Museum of Natural History has been leading scientific expeditions to the world's greatest natural areas. In celebration of our 125th anniversary, the Museum has designed a trip around the world by private jet to some of these remote and magnificent places. In the company of Museum scientists who are currently doing fieldwork in these areas, we will follow in the footsteps of Roy Chapman Andrews, Theodore Roosevelt, Margaret Mead, Carl Akeley and other great Museum explorers of yesteryear.



A private SwissAir airbus, reconfigured with 90 first-class seats, will take us along this exciting route. Highlights include rarely-visited Cuba; Brazil's mighty Amazon River; the massive stone heads on Easter Island; New Guinea's Sepik River and lush jungle; the orangutans of Borneo; incomparable Beijing; Mongolia's capital, Ulan Bator; ancient cities of Myanmar (Burma); the lemurs of Madagascar; Tanzania's spectacular Serengeti; and the prehistoric caves of France.

Join us for an unusual and extraordinary adventure in celebration of 125 years of scientific exploration.

Cuba

Amazon River

Easter Island

Rarotonga

Papua New Guinea

Borneo

China

Mongolia

Myanmar

Madagascar

Tanzania

Dordogne, France





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The Look of Food

If it's pretty, does it taste better?

by Raymond Sokolov

As so often in years past, the official topic of this year's Oxford Symposium on Food and Cookery was both profound and provocative: "Look and Feel." Indeed, some of the 200-odd scholars, cooks, food writers, and foodies assembled at Saint Antony's College managed to make this a positively provoking subject.

For the most part, Clio, the muse of history, was well served in Oxford, with a varied menu ranging from Gillian Riley's remarkable investigation of luxury white foods in medieval and Renaissance Italy to Philip Iddison's rundown on Thai food wrapped in leaves or dough. José Rafael Lovera of Caracas explored this same theme in Latin America, where a whole lexicon of foods prepared and presented in vegetable leaves, from *tamales* to the confection called *alfandoque,* shows off the human genius for simple refinement in decoration and in culinary technology.

These papers, although they quite properly confined themselves to the basic job of cataloging special cases of food presentation, implicitly raised what I took to be the real subject of the symposium. To what extent does the appearance of food affect its flavor (or to use the jargon term, its *organoleptic* qualities)?

On the one hand, Lovera showed how corn and plantain and other indigenous South American leaves protect the food they wrap from dehydration or rotting and make it convenient to manipulate durin cooking or transport. But he was also car ful to mention, in almost every case, th special taste contribution the leaves then selves make to the foods they contain. I an example exotic even for him, he men tions the *frailejón* (*Espeletia schultzii*), plant of the high Andes: "People use i leaves for wrapping butter and homemad cheese, which are sold in the nearby vi lages. This leaf transmits to those produc certain organoleptics distinguishing ther from other manufactures, so that if the are tasted, Andean butter and chees would be immediately differentiated fro the common ones."

Of course, not every form of food pre



Dyed rice wafers are the decorative medium in the Philippine village of Lucban.
Edilberto N. Alegre

ation is meant to add, however subtly, ne flavor. Decoration for decoration's is common but will often have a or psychological effect on the percep- of food. The German aphorist Georg ntenberg once observed that steak ld not be appealing to eat if it were cut a scissors.

arole Bloom of Carlsbad, California, early a believer in the importance of a orative presentation. She styles herself *ssière* and has made herself an expert ecorating pastries and confections gold, which, she admitted in her Ox- paper, "does not have any nutrients, does it have any taste or aroma."

certainly does glitter, though, and the e kind of bright appeal is the goal of much flashier, more demotic food dec- ions prevalent in certain villages of the ippines. Such ephemeral food decora- , disconnected from taste enhance- t or even eating, may reach its plane- height on May 15, during the festival an Isidro Labrador, patron of Filipino ners. Doreen Fernandez came to Ox- with wonderful pictures of the amaz- y florid festival at Lucban in Quezon vince. There, the entire community ex- les into color with *kiping,* brilliantly d rice wafers.

o make them, rice flour and water are ed and then colored fuchsia, emerald, milion, or sunshine yellow. The paste is ead on *kabal* (*Fragraea racemosa*), or ana leaves, and left to dry. Then the shed wafers, about seven inches long, stripped away, deep-fried in oil, and ped into sugar syrup or coconut jam. ple do eat these wafers, but during the Isidro harvest festival, they are hung all over town as *pahiyas,* suspended els. Fernandez writes:

e *pahiyas*] may be hung in rows so that move in the wind; or made to pave se fronts or form decorative patterns.

American Museum of Natural History

FRANCE

CRUISING THROUGH PROVENCE

JUNE 23 - JULY 3, 1994



The Rhone River wends its way through Provence, one of France's most picturesque regions. Lovingly captured on canvas by Van Gogh, Gauguin, Cezanne and others, it is a beguiling region that blends history, culture and natural beauty to perfection.

A team of Museum experts accompany us as we cruise up the Rhone aboard the 5-star m.s. *Cezanne* from Martigue to Viviers. We will discover the splendor of ancient Rome as exemplified by the ruins in Arles, Viviers, Nimes and St. Remy's environs. Cities and towns rife with medieval remnants, such St. Gilles, Aigues-Mortes, Avignon, Les Baux-de-Provence and Aix-en-Provence, add to the historic atmosphere of our itinerary. Not to be forgotten, we will also enjoy the sublime beauty of the countryside, including the magnificent Luberon range and the isolated marshes and sand dunes of the Camargue. Join us for this special journey through southern France.



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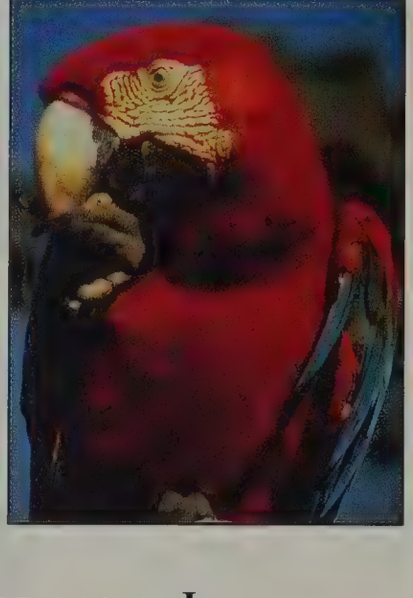
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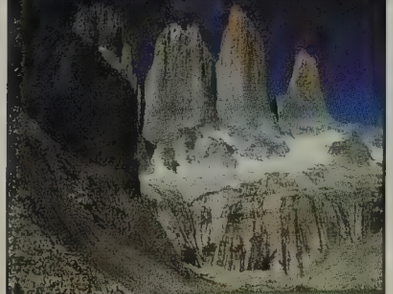


WINTER LAND TOURS

Belize: Reefs, Rain Forests and Maya Ruins
January 25 - February 3, 1994

Belize's renowned barrier reef teems with marine life while inland, its mountains and rain forests abound with wildlife. Discover Belize's natural wonders and impressive Maya ruins as we explore Chan Chich, Chaa Creek, Mountain Pine Ridge, Xunantunich and Ambergris Caye.



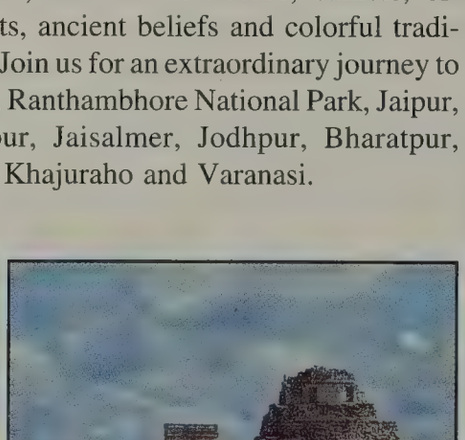


A Passage through India
Including the Palace on Wheels
February 1-21, 1994

India is an ancient and exotic land of ornate temples, massive fortresses, camels, elephants, ancient beliefs and colorful traditions. Join us for an extraordinary journey to Delhi, Ranthambhore National Park, Jaipur, Udaipur, Jaisalmer, Jodhpur, Bharatpur, Agra, Khajuraho and Varanasi.

The Patagonian Andes of Chile
January 29 - February 12, 1994

With high, wind-swept plains, mountains, deep fjords and glaciers, southern Chile is a naturalist's paradise. Explore this remarkable area at the ends of the earth where the Andes culminate in magnificent Torres del Paine National Park.



Mexico's Maya and Olmec Heritage
January 23 - February 5, 1994

Over 1,000 years ago, the ancient Maya and Olmec of Mesoamerica built magnificent cities and ceremonial centers. Join us as we explore Chichen Itza, Uxmal, Coba, Tulum, Palenque and other archeological sites of Mexico's Yucatan Peninsula, a treasure trove of ruins from these great civilizations.

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Especially they are made into the *aran* (chandeliers), a basic shape: tied by stri individually, to circular frames which then assembled into window-size, c storey or two-storey chandeliers.... chandeliers may be in spirals.... They be combined with fruits or foods.... stiff, hard *kiping* may also be softened (plastic bag or in a slightly damp cloth) shaped into flowers: roses, orchids, sunfl ers, sampaguitas, anthuriums.... It may crumbled or broken into pieces and use a mosaic—to form a mural on a housefr or to ornament plain surfaces. (In the chu this year, for example, in front of the m altar, was an arrangement of mortar, pes and plow, all *kiping*-studded.)... The gra vegetables and fruits are the basic dec tive elements, the palette from which townspeople create their edible, ephem art. There are, however, deviations. Du martial law, there were various table with life-size dummies dressed in milit fatigues and bearing guns. This year th were telephone linemen (reflecting the l of, and clamor for, telephones and te phone service).... One year the *leche* (custard) maker saved a year's worth eggshells and made a mural covering whole housefront.

This orgy of edible decoration ce brates the production of food itself, b says Fernandez, "It is food art express the joy of being Lucbanin and alive— one's own town in this bright Maytime.

In Afghanistan, they also celebrate s cial occasions with a burst of color, bu Helen Saberi described it, the ritual *qymaq chai* is a more restrained and m terious business than the hanging of gau *pahiyas* in Lucban. *Qymaq,* or *kaymak* the clotted cream made from the milk water buffalo all over the Middle Ea *Chai* is tea, but in the case of *qymaq cha* starts as green (unfermented) tea, tu into a dark red beverage with the orga oleptic qualities of black (fermented) t and is served with *qymaq* floating on it.

In the recipe Saberi acquired throu her marriage to an Afghan, green tea boiled with bicarbonate of soda and th poured several times from a height to a ate it. How does this process change tea's color? Why is it done?

Symposiasts got a succinct answer fr the food-science writer Harold McG not present but available on the Inter through his computer. McGee modem an explanation relayed to attendees in C ford that (*a*) coloring occurs in tea when phenolic molecules are "aggregated" ther by oxidizing enzymes during the f mentation of black tea ("the same proce that blackens bananas or pinkens po toes") or by plain oxygenation; (*b*) bic

Helen Saberi's *Qymaq Chai*

For the *Qymaq*:

2 cups whole milk
2 teaspoons cornstarch
¼ cup heavy cream

. Add the milk to the pan and bring to the boil. Reduce the heat and stir in the cream.
. Sieve in the cornstarch, stir to mix, and then whisk until frothy. Leave on low heat. A thick skin will form on the top of the mixture. This should be removed from time to time and collected in another pan until only a small amount of milk mixture is left.
. Place the pan with all the collected qymaq (the reserved "skins") over low heat and leave for a couple hours more. Then keep the *qymaq* in a cool place until needed.

For the tea:

1¾ cup water
6 teaspoons green tea
¼ teaspoon baking soda
Ice cubes
1 cup plus 2 tablespoons milk
1–3 tablespoons sugar, to taste
3 tablespoons qymaq
2 teaspoons ground green or white cardamom seeds

1. Put the water in a pan and bring to a boil. Add the tea and boil for about 5 minutes, until the leaves have opened up. Add the baking soda and continue to boil for a couple of minutes more. The tea will rise to the top of the pan while boiling. Each time it does, add an ice cube to reduce the temperature. Remove the pan from the heat and allow the tea leaves to settle. Strain off and discard the leaves.
2. Put an ice cube into another pan and pour the tea over it from a height in order to aerate the tea. Repeat several times, pouring from pan to pan, adding an ice cube each time until the tea becomes a dark red color.
3. Put the pan back on the heat and add the milk. The color of the tea will now be a purply pink. Slowly heat it to just below the boiling point, then stir in the sugar and cardamom.
4. Pour the tea into cups and add 2 teaspoons of *qymaq* on top.

Yield: 4 cups tea

ate reduces the acidity of the liquid the hydrogen ions of the phenolics nselves, which promotes coloring. McGee speculates that bicarbonate may ply replace wood as the original alka- r. He goes on to surmise that the pour- in the Afghan recipe may have origi- ly been done to cool the beverage and t its color-enhancing effect was an acci- ital discovery. All this makes sense if ck tea was once more costly or more stigious than green tea. Then again it y simply be, as McGee also suggests, t the mysterious color change itself of- s guests a desirably magical bit of food formance. It wouldn't taste quite the ne just brewed from tea bags, except in lind tasting, maybe.

But even a blindfold would not have nked out the theatrical effect of the mposium's most astonishing "lecture." was also the shortest paper delivered all ekend. I reproduce it here in full:

Organoleptic Deconstruction
in Three Movements, by Alicia Ríos
Demonstrations and Experiments

An exploration of the texture, sound and pearance of various substances out of ir usual context.

Ríos barely spoke. She chose to "per- m" the act of eating before us, while locating it, wrenching it from its usual contexts, and making us consider it as sound and touch and feel. For the sound, she played recordings made with a microphone held close to her husband's mouth while he chewed. The result gave new meaning to the phrase "pigging out." For touch, she "chewed" various foods with her fingers, making a colossal pink and white mess. For feel, she lay down on a transparent plastic mattress filled with potato chips and crushed them with the undulations of her body.

The assembled symposiasts were convulsed with laughter, but for the first time during the entire symposium, and probably in their gastronomic lives, they had really been confronted with the literal "look and feel" of eating.

Later on, Ríos cast further light on the matter, revealing a small but defining difference in the ways that the English and the Spanish define themselves through the presentation of food. In her native Spain, she said, she had been able to fill her air mattress with only three large bags of potato chips. In England, the bags were much, much smaller. The same stunt performed at Oxford had required several dozen tiny packets.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.

American Museum of Natural History

IN THE WAKE OF THE GREAT WHALES

Cruising the Baja Peninsula
February 4–15, 1994
Aboard the 39-cabin M.V. Sea Lion



Experience the spectacular desert wilderness of the Baja Peninsula and the rich marine environment that surrounds it. See multitudes of seabirds, manta rays, sea lions, tropical fish, enormous cacti, rare plants, flowers and the great whales up-close during their peak courting and breeding season. A team of American Museum lecturers who are eager to share their insights into and enthusiasm for the splendid plant and animal life of the Baja Peninsula lead this land and cruise program.



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Feed Me! Feed Me!

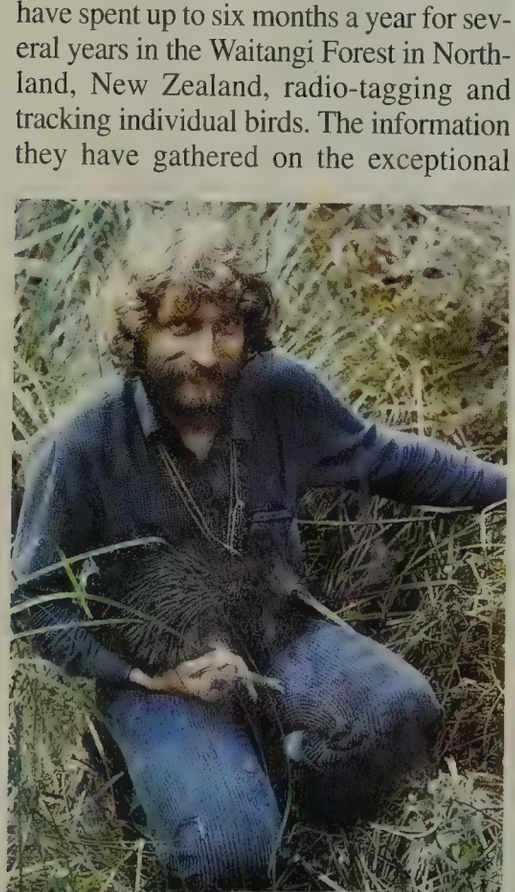
In the Falkland Islands, a hungry, almost fully grown gentoo penguin chick chases its parent, demanding a mouthful of regurgitated krill. The parent may seem to be shirking its duties, but the chase helps insure the equal distribution of seafood between two offspring—the usual number in a gentoo clutch. At hatching time, in late November, one chick may emerge a day or so ahead of its sibling and quickly gain a weight advantage. This edge allows it to push the younger chick aside at feeding time in the nest. Unable to distinguish between the two, the parents simply feed the closest begging mouth.

Things even out about a month after hatching, when the chicks become mobile and begin to wander around the colony. When an adult gentoo emerges from the sea after some ten hours of fishing, it returns to the nest and calls for its chicks, which come running. After regurgitating some food, the parent often flees and will run some distance before stopping to feed its chicks. According to Lloyd S. Davis, an ornithologist at the University of Otago in New Zealand, such feeding chases, which are common in gentoo colonies, give the "disadvantaged" chick equal access to the food. Since a satiated chick is less inclined to pursue a meal, its hungry sibling will be fed without interference. If a couple has only one chick, feeding chases are rare and very short. By February, gentoo parents feed their offspring less and less frequently. Hunger and instinct then motivate the chicks to fish on their own.—*R. A.*

Photograph by Frans Lanting
Minden Pictures

Michael Taborsky (page 50) adopted brown kiwis as a study subject some ten years ago, while he was on a lecture tour of New Zealand. Taborsky had been studying reproductive systems in fishes, when a colleague piqued his interest in the possibility of applying his expertise to kiwis. The need for solid field information about how kiwis raise their young led Taborsky to undertake the challenge of following these secretive, nocturnal birds in the wild. A research scientist at the Konrad Lorenz Institute of Comparative Ethology in Vienna, Austria, Taborsky and his coauthor, **Barbara Taborsky**, a doctoral student at the University of Vienna, have spent up to six months a year for several years in the Waitangi Forest in Northland, New Zealand, radio-tagging and tracking individual birds. The information they have gathered on the exceptional





breeding habits of kiwis can shed light on avian mating systems in general. In the course of their work, the Taborskys also discovered that a single feral dog had eradicated half of the Waitangi Forest kiwis, one of the last substantial populations of the birds. The incident, which led to more conservation measures, is discussed in "The Horn of Triton" by Stephen Jay Gould (*Natural History,* December 1989). More information on various kiwi species can be found in *The Incredible Kiwi* by Neville Peat (Auckland: Random Century New Zealand, 1990) and *Kiwis: A Monograph on the Family Apterygidae,* edited by Errol Fuller (Shrewsbury, England: Swan Hill Press, 1991). The latter also contains drawings and paintings by Ray Harris-Ching, whose work appears in this month's kiwi article and on the cover.

Russian journalist and photograph**Alexander S. Milovsky**'s ongoing stu of indigenous religious traditions with the former Soviet Union (page 34) has r sulted in ten books on Eurasian religio arts, edifices, and practices. Among h *Natural History* contributions are "Tub akou's Spirit Flight" (July 1992), on Siberian shaman, and "The Death of Wi ter" (January 1993), which documente festivals from Moldova to Azerbaijan co nected with the rebirth of spring. This tim Milovsky has visited the Khanty-Man National District of northeastern Siberia observe the ancient bear festival. Reache by telephone in Moscow during last fall governmental crisis, he took the lon view: "Whatever the outcome," he com mented, "there will always be bear fest vals in the village of Sosvinskaya." Fo additional reading about bear festival Milovsky recommends "Bear Ceremonia ism in the Northern Hemisphere," by A Irving Hallowell in *American Anthropolo gist,* vol. 28, no.1, January–March, 192 pp. 1–175.



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